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## THE ABUSE OF INTESTINAL INTUBATION

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The introduction of nasogastric suction and intestinal intubation as adjuvants in the treatment of intestinal obstruction has, rightfully, been credited with a significant contribution in the lowering of mortality rates in these conditions.<sup>9</sup> However, as too often is true in medicine, a procedure which when utilized properly is a benefit, abuse rather than use of the same procedure can be markedly deleterious to the patient. Paine<sup>7</sup> has most adequately summarized the beneficial role of gastrointestinal decompression in surgery. The "failures" credited to intestinal intubation, the altered attitudes and wishful thinking in the management of obstruction when intubation has been accomplished successfully and the complications we have been unfortunate enough to witness point all too clearly to the fact that abuse of intestinal intubation not only exists but is far from uncommon.

Kleinsasser<sup>4</sup> has written an excellent summation of the various complications associated with gastrointestinal decompression and cites such things as disturbances in fluid and electrolyte balance, ulcerations of the larynx and esophagus, perforation of the esophagus, stomach and small intestine, knotting of the tube, inability to withdraw the balloon-tipped tube and several other mechanical hazards. While many of these complications are inherent in a situation wherein attempts are made to thread some 20 feet of the gastrointestinal tract on 5 or 6 feet of tubing, many complications are avoidable and represent abuses of a good medical adjuvant.

Probably the two outstanding abuses of intestinal intubation are: 1) the failure to realize the inherent dangers which can be associated with intubation and 2) the failure to realize the limitations of intubation and its role as an adjuvant, only, in the therapy of intestinal obstruction.

Failure to be fully cognizant of the inherent dangers and difficulties of intubation

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has resulted in two major ills—a) the relegation of the actual intubation and subsequent management thereof, to the least experienced of house officers and through them to the nursing staff; b) the unwise selection of a tube predicated on its reputed ability to be more easily passed through the pylorus and the increased intraluminal size of the intubation tube.

Observation of the abuse of long intestinal tubes in several hospitals in various sections of the country points up the fact that inadequate indoctrination of the house officers stems from inadequate appreciation of the use of the tubes by the responsible men who tell the residents to "*insert a long tube*". The primary requirement of a long intestinal tube is as much minute-to-minute control of the tube as is possible of attainment. This implies immediately that any tube which has mercury in the balloon-tip or one in which mercury is introduced to facilitate passage through the pylorus has compromised the minute-to-minute control. The bolus of mercury cannot be controlled or removed and the tube is entirely at the mercy of uncontrolled and uncontrollable intestinal peristalsis. Again, a balloon-tipped tube without mercury in which the balloon cannot be decompressed violates the principle of controllability since intestinal gases will permeate the balloon leading to obstruction<sup>3</sup> and, on occasion, intussusception.

One of the very real abuses is that associated with the initial intubation when, before insertion, inadequate testing of the tube results in failure even though the tube has been passed beyond the pylorus successfully. A thorough check of the tube must be made, the patency of the lumina ascertained, the balloon checked for leakage, the volume of air required to inflate the balloon to an adequate sized bolus determined and finally, a check that the luminal indicators are accurate and not reversed. Following this initial inspection it is not enough for the tube to be passed into the stomach and instructions left with the nurse to "*advance the tube one-half inch every half hour*". The decision to employ long tube decompression carries with it the implication that a trained and competent individual is committed to the bedside of the patient until the tube has accomplished the purpose for which it was intended. The stomach contents must be evacuated and the balloon-tip placed accurately, preferably by fluoroscopy against the pylorus. The usual aids in pyloric relaxation and positioning of the patient should be employed. The commonly accepted right lateral decubitus may not be the ideal position in the face of distention and the initial fluoroscopy may be of very considerable value in deciding upon a right lateral, prone, semirecumbent or other position. Gentle irrigation of the pylorus with warm normal saline solution may be of considerable help in relaxing the pylorus. Moderate inflation and decompression of the balloon may give mechanical stimulation for peristalsis to carry the tube into the duodenum. The inflation of the balloon and the movement of the plunger on a 50 cc. syringe will differentiate antral and duodenal contractions. It seems almost ridiculous to mention that the balloon is inflated and allowed to remain so only after the tube is in the duodenum but time after time we have witnessed, on various services, an unsuccessful intubation due, among other reasons, to inflation of the balloon as soon as the tube was introduced into the stomach. Once the tube is progressing satisfactorily, hand suctioning may on oc-

casation be more beneficial than the various types of mechanical suction. It is also important to follow the progression of the tube until the area desired is reached, the balloon then is deflated and the tube allowed to remain stationary rather than having peristalsis continue to attempt to move it past the block with all the attendant dangers of necrosis, knotting and perforation. Fixation of the tube at the nose with a mercury-filled balloon in the intestine may cause severe peristaltic attempts to move the bolus onward causing linear necrosis of the intestine.<sup>6</sup> All of this implies that a physician is in attendance until success has been attained.

Unfortunately, the abuses associated with the failure to pass a tube successfully are not the major abuses associated with this procedure. Granted that all too often prolonged attempts waste precious time in the definitive management of an obstruction, the real abuses appear in those individuals where a tube has been passed successfully. It is under such circumstances that delay, wishful thinking and misinterpretation of the role of the long tube can and does cause the most serious damage. The treatment of a mechanical obstruction must be definitive surgery. The treatment of strangulating obstruction requires immediate surgery as soon as the patient can be prepared and without the delays associated with intestinal intubation. It is nonsensical to assume that decompression alone has solved the underlying organic pathology. Why the mere disappearance of gas-filled loops on subsequent abdominal films following successful intubation and suction should lead to further postponement of definitive surgery is difficult to understand. However, analysis of the complications associated with intubation demonstrates that most of these are associated with prolonged abuse of intubation as a definitive measure rather than its utilization as a preoperative and postoperative adjuvant. While necrosis, knotting and perforation can occur rapidly, these and the subsequent inability to withdraw the tube are usually associated with the utilization of the tube for a period of several days. Prolonged usage of these tubes is also associated with an increased rate of upper respiratory complications associated with excessive nasopharyngeal secretions from irritation of the tube, otitis media, nasopharyngeal abscesses and stenosis of the larynx and esophagus.<sup>4, 7</sup> In addition, it must be remembered that a tube in the small bowel does not, necessarily, remove accumulated fluids in the stomach itself and vomiting with aspiration can and does occur. The following cases which we have seen in the past two years serve to emphasize the abuse rather than the use of intestinal intubation.

Case 1. W. B., a 41 year old white woman, was admitted to the hospital with a diagnosis of partial intestinal obstruction secondary to metastatic carcinoma of the cervix. She was treated by intestinal intubation with a long tube containing a mercury-filled bag at the end (Harris). Distention promptly subsided and the tube was clamped. On roentgenogram the tube was seen to be in the region of the ileocecal valve at this time. Considerable difficulty and multiple attempts at traction were used to remove the tube. Twenty-four hours later the patient developed signs of generalized peritonitis. At surgery a small bowel resection was done for multiple perforations. She died in the immediate postoperative period.

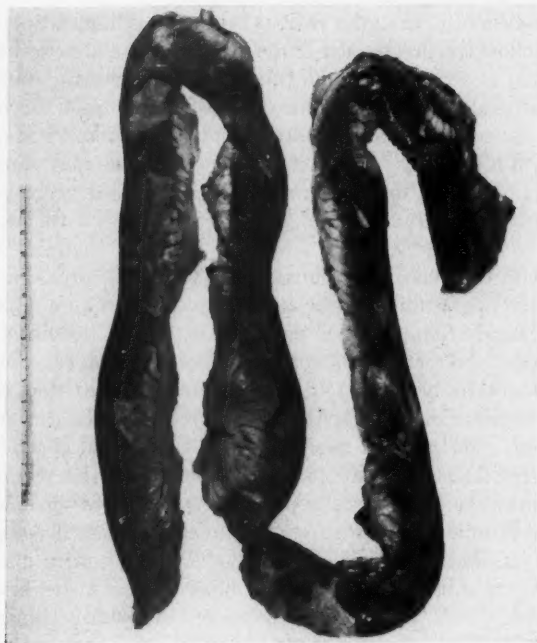


FIG. 1. Case 1 (A) Serosal view showing pressure necrosis of the intestine

*Comment:* (1) Had a tube with a deflatable bag been used this sequence of events would never have happened.

(2) If the tube cannot be removed by gentle traction the excess should be cut off and the patient allowed to pass the tube per rectum with the realization that surgery might be necessary for removal.

Case 2. H. J., a 64 year old Negro man, was admitted to the hospital with a diagnosis of intestinal obstruction secondary to a carcinoma of the splenic flexure and a Harris tube was passed. A cecostomy was successfully performed. Ten days later it was necessary to perform an exploratory celiotomy because of small bowel obstruction secondary to adhesions. The Harris tube which had been in place since the original operation had become knotted and did not function satisfactorily enough to prevent the distention.

*Comment:* (1) Intestinal intubation has little place in the initial decompression of obstruction of the large bowel.

(2) Had a deflatable balloon tube been used initially the possibilities of knotting would have been much less since the purpose was to decompress the small bowel only until the cecostomy took over.

(3) The Harris tube was left in place an extended length of time.

Case 3. P. B., a 55 year old white woman, underwent a lysis of adhesions 12 days following a hysterectomy and bilateral salpingophorectomy. Prior to this operation a Harris tube had been inserted and was in the mid small bowel. At the second operation an ob-





FIG. 2. Case 1 (B) Open view of resected segment

structing adhesion was found in the terminal ileum. Roentgenograms following surgery showed the ileal gas to be decreased but the small bowel above the tube more distended. On removal of the tube the balloon was found to have a large amount of air which had not been present on introduction. It was thought that this represented gas which had diffused into the balloon and caused the obstruction. The patient responded well following the removal of the tube.

*Criticism:* (1) A balloon should be used in which excess air can be removed with the tube in place.

Case 4. A. G., a 71 year old white woman, was admitted to the hospital with a diagnosis of partial mechanical intestinal obstruction due to adhesions. A Miller-Abbott tube using mercury in the bag was inserted and the patient responded dramatically with relief of distention and recurrence of normal bowel movements almost immediately. Twenty-four hours later it was found that the tube could not be withdrawn completely even after unsuccessful attempts to withdraw the mercury. Roentgenograms taken at that time showed several knots in the tube which had coiled in the esophagus. Under fluoroscopy after having the patient swallow mineral oil the tube was gradually removed with difficulty.

*Comment:* (1) The addition of mercury to a deflatable balloon tube defeats its purpose. The mercury rarely if ever can be withdrawn successfully.

Case 5. E. A., a 53 year old Negro man was admitted to the hospital with a diagnosis of intestinal obstruction which at surgery was found to be a volvulus of the sigmoid with a portion of ileum involved in the process requiring both a small bowel and large bowel resection. The immediate postoperative course was stormy but he gradually improved with his main problem being that of intermittent distention thought to be due to adhesions



FIG. 3. Case 3 Arrows point to dilated gas filled balloon. Note small bowel obstruction proximal to this area.

which responded well to intestinal decompression with a Cantor tube. It was thought that it would be easier to attempt to let the tube pass from below due to its location in the terminal ileum. The patient, however, misinterpreted the instructions and swallowed the proximal end before the distal end appeared. After 2 weeks of waiting the tube did not appear and it was necessary to do a transverse colostomy to remove the tube. The patient recovered from this and was discharged.

*Comment:* (1) This again shows the advantages of having the type of intestinal tube over which you have minute-to-minute control.

(2) This is another example of the fact that some tubes will not pass through the entire intestine and must be removed surgically.

Case 6. G. P., a 51 year old white woman, who preoperative to a radical hysterectomy had a Harris tube inserted into the small bowel. During the postoperative period it developed a knot but continued to function satisfactorily. Attempts at removal were difficult and removal was attempted by a process of constant traction without success. It was then cut at the nose to be passed per rectum. Several hours after this the patient developed signs of peritonitis and exploration revealed a partial volvulus of the ileum around the tube with areas of early necrosis of the small bowel. The tube was removed by ileotomy and the areas of necrosis reinforced by serosal apposition. The patient tolerated the procedure

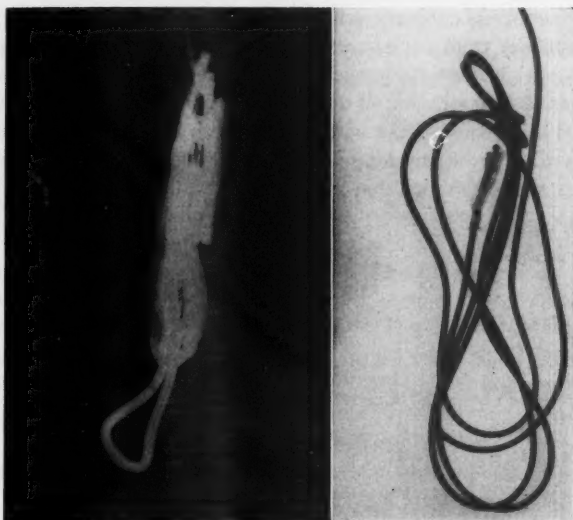


FIG. 4. Case 4 (A) Roentgenogram of tube coiled in the esophagus. (B) Tube following removal.

poorly and died 12 days later having had persistent oliguria and azotemia following the last operative procedure.

*Comment:* (1) Mercury filled balloon tubes present difficulties in removal and for that reason should not be used.

(2) Persistent efforts to remove a tube may lead to necrosis of the bowel wall as demonstrated here.

Case 7. M. V. W., a 68 year old white woman, was admitted to the hospital with a huge ventral hernia with partial obstruction. Because of the tremendous size of the hernia a Miller-Abbott tube was inserted with mercury in the bag and her partial obstruction was relieved. The Miller-Abbott tube subsequently could not be removed and could not be made to progress distally. Because of severe cardiac disease and other complications the patient was not a candidate for a herniorrhaphy. Since the tube could not be removed, would not progress and symptoms of obstruction began to recur, ileotomy and removal of the tube was done. At the time of surgery the balloon was found to be broken in the intestine and only part of the mercury was recovered. Postoperatively beads of mercury came through the abdominal incision for 10 days. No abscesses or other difficulties with the mercury developed subsequently.

*Comment:* (1) While it has been said that free mercury in the intestinal tract causes little or no difficulty and in this case was worrisome but not deleterious to the patient, others have reported fistula formation and abscesses especially with lodging of the mercury in diverticula.<sup>1, 2, 5</sup>

#### SUMMARY

The contributions that nasogastric suction and intestinal intubation have made to the lowering of mortality rate in intestinal obstruction is well recognized.

However, the problems encountered when these tubes are not used correctly occur more commonly than is generally realized. The major difficulties arising in intestinal intubation are those associated with inexperience, failure to maintain minute-to-minute control, lack of appreciation for its role as an adjuvant only and prolonged utilization of the tube. It has been the purpose of this paper to illustrate several of these problems by means of case reports in the hope that the abuse of intestinal decompression may be lessened.

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## PHYSIOLOGICAL ASPECTS OF PROTEIN DEPLETION AND RESTORATION IN SURGICAL PATIENTS

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Increased interest in the nutritional management of surgical patients has reduced the frequency of complications, the morbidity and mortality rate. It has improved the poor-risk patient, rendered many planned operations unnecessary, decreased the transfusion requirements and shortened convalescence. These various benefits justify an occasional review of some of the important nutritional and metabolic relationships to disease, trauma and stress.<sup>13, 52, 56</sup>

*Recognition of the malnourished patient* is not difficult. The history of inadequate diet and recent weight loss and consideration of the character of the underlying disease are usually sufficient.<sup>70</sup> Dependent shifting edema in the absence of cardiac or kidney disease and severe anemia are always suggestive of protein starvation. The elderly patient with recent weight loss, debilitating disease, infection or carcinoma, who may also be unwilling or unable to eat, usually has a serious protein deficiency. Such a patient also having protein loss as transudates, exudates or repeated hemorrhage constitutes a serious emergency and presents a difficult task of protein replacement, as mere nitrogen equilibrium may be almost impossible to attain. On the other hand, an additional period of starvation may be unwittingly imposed by the surgeon, sometimes preoperatively but more commonly postoperatively by over enthusiastic intravenous fluid therapy and over cautious delay in feeding. The anorexia, malaise, weakness, lassitude and asthenia, so characteristic of protein starvation may be attributed to other causes and the treatment misdirected. Death attributed to the injury or disease may actually be due to starvation.

Intravenous solutions should be properly selected and their prolonged use should be avoided wherever possible. Many of our electrolyte problems are created in the hospital by over zealous therapy, injudicious intubation and by routine orders. Nitrogen loss may be overlooked, and the important osmotic effect of serum protein resulting in fluid shifts may not be appreciated. Many patients receiving intravenous fluids can take and utilize liquids by mouth. Certain electrolyte deficiencies can be better managed orally and in this manner certainly, proper nutrition can be more adequately corrected and maintained.

*Weight loss* is perhaps the most striking single guide to progressive protein depletion. A negative nitrogen balance of only 10 Gm. daily for 10 days represents a loss of 625 Gm. of protein. This amount of protein in terms of muscle mass which is 80 per cent water would be about 3000 Gm. and represent a 6 pound weight loss. A rather marked recent weight loss in a nonobese patient could indicate a serious protein depletion. In starvation much of the needed calories are

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derived from plasma and tissue protein. Only 500 calories derived from this source would represent 125 Gm. of protein or approximately 600 Gm. body tissue. Weight loss may be masked by edema of malnutrition and only revealed following loss of fluid by moderate salt restriction and nutritional improvement.

*Anemia* is characteristic of protein depletion. The cell mass and total circulating hemoglobin is always diminished. Malnutrition should be more frequently recognized as its cause. The red cell count and hemoglobin per cent are unreliable due to the diminished blood volume usually present. Preoperative evaluation by hemoglobin per cent or red cell count may be misleading.

The total *serum protein* level is not a reliable index to protein deficiency. In the presence of dehydration and hemoconcentration it may be reported as essentially normal, although the patient may be seriously depleted of body protein. In such situations the true value may be revealed only after adequate fluid replacement. A serum protein level of 7 mg. per cent on admission may fall to 5.5 or 6 mg. per cent after hydration. The albumin fraction is most important nutritionally as a high serum globulin may be present in certain diseases and result in a normal or only slightly decreased total serum protein level in a patient with definite protein deficiency.<sup>57</sup> In fact the term hypoproteinemia itself is misleading as it does not imply the total body protein status. Its elevation during protein replacement is delayed as the total body deficits are simultaneously corrected. If priority exists in any tissue it appears to be in the liver, as hemoglobin restoration may exceed that of plasma protein.

The *characteristics of protein depletion* whether due to decreased protein intake, or loss by transudates, exudates, repeated hemorrhage, vomiting or diarrhea, or by impaired ability to synthesize new tissue proteins as in liver disease, are the same. The effects are well known.<sup>39</sup> Nutritional edema with paralytic ileus, or even intestinal obstruction, is frequent. Diarrhea from mucosal edema and ulceration is common. Wound disruption,<sup>65</sup> decubitus ulcers,<sup>47, 48</sup> and delayed healing<sup>38, 53</sup> are the rule. Decreased blood volume with circulation impairment ("chronic shock"),<sup>15</sup> impaired kidney and liver function and depressed antibody production<sup>12</sup> with lowered resistance to infection<sup>5</sup> may all be present in a single patient.

#### NITROGEN BALANCE

*Nitrogen balance studies* are not essential to adequate protein replacement; however, in certain cases a few days determination of daily urinary, stool and exudate nitrogen losses may be most enlightening. An accurate comparison with the actual measured protein intake reduced by the factor 6.25 to its nitrogen equivalent may be alarming. A negative balance must be corrected early by eliminating unusual losses and increasing protein intake by some method of forced feeding; otherwise, accumulated protein deficits may become hazardous.

Metabolic processes of catabolism and anabolism are continuous, varying with activity and increasing with fever, disease and trauma. The average daily urinary nitrogen in a healthy adult is 8 or 9 Gm. and fecal nitrogen 1 Gm. The adult protein requirement in health is therefore its equivalent, 65 to 70 Gm. usually esti-

mated as 1 Gm. per kilogram. In illness this may be increased two or threefold and the protein intake may be markedly reduced by anorexia or limited by emesis, ileus or coma. When adequate exogenous protein is not available to meet the anabolic requirements the endogenous source alone is utilized. Depletion of tissue protein soon occurs. Weight loss and impairment of physiologic functions will result.

It is not enough to merely establish nitrogen equilibrium in the malnourished patient. The protein deficit must be corrected. A significant excess of the daily requirements as measured by total nitrogen losses must be provided, accepted by the patient and utilized. Weight gain in the absence of water retention is an almost certain indication of positive nitrogen balance.<sup>26, 37</sup>

*Extrarenal nitrogen loss*<sup>43</sup> such as in transudates, exudates, hemorrhage and diarrhea may be great. In severe burns the nitrogen loss by bleb fluid may be 3 to 6 Gm. daily. When infection supervenes the loss may be several times as great. In pleural effusion and ascites large volumes of protein in concentrations of 1.5 to 2 Gm. per cent may be lost. In draining empyema cavities, peritonitis, decubitus ulcers and draining abscesses in which the protein concentration is much higher, the protein loss is even greater. These patients all characteristically lose weight rapidly.

*Increased urinary nitrogen* follows severe injury,<sup>51</sup> burns,<sup>8, 10, 16</sup> infection,<sup>34</sup> operation,<sup>2, 3, 4, 68</sup> and even immobilization, by splinting of fractures or bed rest.<sup>26, 36, 64</sup> This is a manifestation of the pituitary-adrenal mechanism, "stress",<sup>58</sup> occasionally referred to as "traumatic protein loss" and presents a fascinating theoretic physiologic mechanism. A constant finding is the rise in 17-hydroxycorticoid and urinary nitrogen excretion and a fall in circulating eosinophils.<sup>46</sup> There is a vague correlation between the rise in urinary nitrogen, the reduction of serum albumin<sup>72</sup> and weight loss. Over simplified it has been stated that the smaller albumin molecules pass through the capillary walls from the serum to the interstitial fluid; the A/G ratio of the serum shifting toward negative and that of the lymph and interstitial fluid toward positive.<sup>31</sup> The proteolytic enzyme concentration in the lymph and interstitial fluid promptly rises,<sup>2, 3, 4</sup> resulting in rapid protein hydrolysis, followed by resynthesis to tissue proteins and final deamination of the amino acids not utilized as such; their nitrogen appearing in the urine as urea and ammonia. Increased catabolism is no doubt a factor in nitrogen loss but a decreased anabolic process is now questioned by many.

The amount of urinary nitrogen loss varies with the severity of the injury or magnitude of the operation,<sup>2, 3, 4, 66</sup> but is not generally influenced by the anesthetic.<sup>40</sup> It is also apparently related to the degree of protein depletion of the patient; it being less in those with hypoproteinemia.<sup>2, 3, 4, 11, 46</sup> This may be evidence of exhaustion of endogenous protein source and therefore evidence of a critical level of vital physiologic activities. In severe burns the urinary nitrogen loss may be 5 to 10 times the bleb fluid and exudate protein loss. It may reach 25 to 35 or more grams daily for 2 weeks and remain 15 to 20 grams daily for 6 weeks. The nutritional requirements therefore are very great.<sup>18</sup> As much as 200

to 250 grams of protein may be required daily in order to maintain nitrogen equilibrium. The morbidity, mortality and the success of the late care of burns are influenced greatly by nutritional management.<sup>8, 9</sup>

Following *major fractures*<sup>24, 25</sup> and other injuries<sup>49, 68</sup> the increased urinary nitrogen loss is prompt and severe. It may subside after several days to a week with increasing activity. In *severe infections* the requirements are further augmented by increased metabolism due to fever.<sup>26, 34</sup>

*Major surgery* invokes a prompt rise in renal nitrogen excretion as in any major trauma. When protein is administered early postoperatively the urinary nitrogen loss further increases. This is greatest in those with adequate protein stores and high serum protein level and less in the depleted patient. We do not agree therefore in the futility of early postoperative feeding<sup>22</sup> for it is the protein starved patient who needs protein most who utilizes it best.<sup>53, 54, 55</sup> In all cases the degree of negative nitrogen balance postoperatively can be decreased and its duration shortened<sup>47, 48, 66, 67</sup> with early and adequate postoperative feeding. With such management complications are less frequent and convalescence is shortened.

*Diminished blood volume* is consistently present in protein depleted patients<sup>2, 3, 4, 7, 43, 47, 48, 49, 53, 54, 55</sup> and constitutes a serious hazard to urgent surgery.<sup>15</sup> Practical methods of determining blood volume are available<sup>6</sup> and the quantitative replacement of its components, cells and plasma is relatively safe.<sup>60</sup> However, it must be remembered that blood replacement is not long retained in the presence of serious tissue protein loss as much of the added plasma protein is promptly transferred in the fabrication of tissue cells<sup>49</sup> which have a 30 to 1 ratio with plasma. A secondary decrease in blood volume always follows in such cases and if uncorrected this may result in mild persistent shock. Oliguria and anuria may follow in a few days postoperatively. This must always be anticipated when the malnourished patient is transfused for emergency surgery. Transfusions should be repeated postoperatively and nutritional management should be started early.

Preoperative restoration of blood volume in the absence of an emergency should always be by high protein nutritional management,<sup>50</sup> for by this method serious deficits, not only in the plasma, but in all tissues including the liver, kidneys, heart, endocrine glands and bone marrow may be restored. The preoperative and postoperative transfusion requirements can thus be markedly reduced. For every 30 Gm. of tissue protein restored there is formed approximately 1 Gm. of plasma protein and 2 to 4 Gm. of hemoglobin.<sup>36, 37, 43</sup> We have corrected a 45 per cent blood volume deficit in a hemoplegic patient with extensive decubitus ulcers in 11 weeks without transfusions by maintaining a strongly positive nitrogen balance with continuous high protein feeding. Red cell maturation averaged 1.9 per cent daily as the erythrocyte count returned to normal. Cell mass restoration was almost complete, increasing from 45 per cent to 92 per cent of normal and plasma volume was restored to 112 per cent of its estimated standard value.

We have made blood volume studies on a series of patients, both well nourished and protein depleted pre and postoperatively and have repeated these studies after quantitative replacement of plasma and cell deficits. We have noted less discrepancy between the anticipated and resulting correction in the well nour-

# BLOOD VOLUME REPLACEMENT

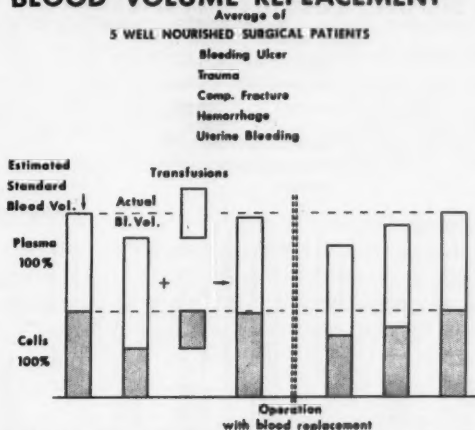


FIG. 1. Average blood volume of 5 well nourished patients illustrating ability to maintain expansion following transfusion. This also demonstrates spontaneous postoperative expansion.

ished. We have also noted less decrease in blood volume postoperatively and a more rapid return to normal levels in the well nourished (fig. 1.).

Those with marked protein deficit as a result of prolonged negative nitrogen balance failed to retain the volume expansion as indicated by post-transfusion blood volume studies. Repeated transfusions and actually, although dangerous, over transfusion was performed in an attempt to restore standard volumes. Normovolemia in the protein deficient state may be seen with high sodium and adequate fluid intake. The postoperative blood volume studies indicated a greater fall than in the well nourished group and in many cases the fall continued rather than reversing itself as the plasma protein was being utilized. Repeated postoperative transfusions were necessary in these patients whose body protein was greatly diminished (fig. 2.).

In many protein deficient patients not requiring transfusion for surgery serial blood volume studies were made during reproteinization. These consistently reveal a rather rapid restoration of plasma volume and cell mass (fig. 3).

While transfusion replacement of circulating plasma protein in a depleted patient is prompt and provides the colloids for normal hemodynamics, it is not well sustained even throughout the period of operation as the disequilibrium of body proteins permits it to be transferred to other tissues. Therefore, when not properly prepared by protein repletion, more blood will be required during and after surgery.

Regardless of the disease or injury or of the medical or surgical procedure contemplated a vigorous effort should be made to correct any existing protein deficit and to maintain a positive nitrogen balance during illness and also pre and postoperatively.<sup>24, 25</sup> The incidence of complications and the success or failure of major operations are greatly influenced by protein nutrition.<sup>19, 20</sup> Certainly it is

## BLOOD VOLUME REPLACEMENT

Average of  
7 PROTEIN DEPLETED SURGICAL PATIENTS

Gangrene, leg amputation  
Carcinoma of the esophagus  
" " " stomach  
" " " colon  
Chr. ulcerative colitis  
Incarcerated hernia, scdity  
Empyema

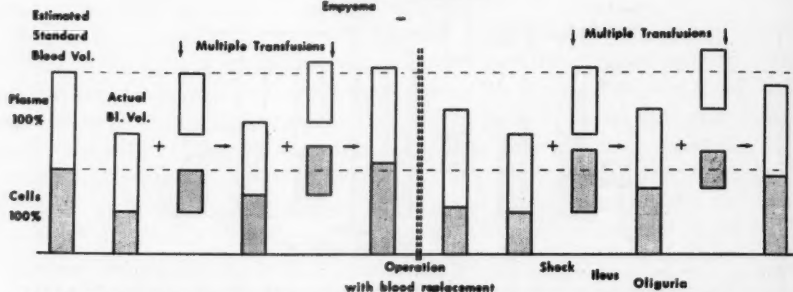


FIG. 2. Graph illustrating inability of malnourished patients to retain volume expansion following quantitative blood volume replacement. The postoperative fall in blood volume was greater and continued longer than in the well nourished group. Repeated postoperative transfusions were necessary to retain normovolemia.

## BLOOD VOLUME STUDY

W.H., 36 yr WM, adm. 18 days post burn  
32% 2° and 3° burn

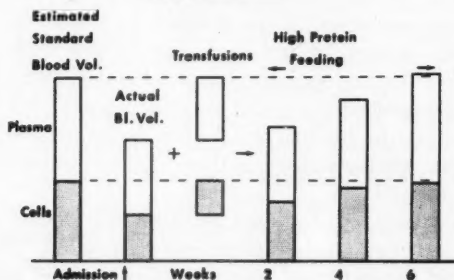


FIG. 3. Graph illustrating "chronic shock" in a protein depleted burned patient. Blood volume expansion was rapid and complete with high protein continuous tube feeding and no transfusions were needed.

futile to expect a major amputation wound to heal in the presence of massive, spreading decubitus ulcers or for a duodenal ulcer to heal in the presence of serious protein depletion and continuing negative balance.

### MEETING NUTRITIONAL DEMANDS

The nutritional requirements of the hospital patient should not be based upon commonly recommended dietary allowances such as proposed by the National Research Council, the Canadian Council on Nutrition, or even as outlined in the



various hospital manuals, including the military as they are not designed to meet the requirements of pathologic states.<sup>52</sup> The caloric requirement may increase to 2500 or 3000 but this is never as great as the protein needs. Such amounts are seldom provided and cannot be consumed by the usual sick patient even with constant urging and spoon feeding by the nurse. It is important that we determine how much food is being consumed. Some form of supplemental forced feeding may be necessary for maximal protein nutrition. The protein requirement may increase many fold.

*Parenteral alimentation* has been disappointing nutritionally and its use is being generally discouraged.<sup>52</sup> It is inadequate in calories and inefficient for proteins as no more than 50 to 65 per cent of the amino acids thus administered are utilized.<sup>41</sup> The protein sparing effect of 10 per cent dextrose or invert sugar slowly administered may establish a more satisfactory nitrogen economy than lower calories plus protein.<sup>68</sup>

*Blood and plasma transfusions* should not be used as nourishment. One occasionally still hears of their use for protein restoration in the hypoproteinemic patient. This is *wasteful* and unless needed for anemia or blood volume expansion, it may be *dangerous*, as a serious overload reaction might result.<sup>50</sup> The hemoglobin of fresh blood is not immediately available for utilization as protein as the life of red cells is approximately 90 days. The protein present in the plasma of one unit (500 cc.) of blood is only 19 Gm. One would therefore need 1500 cc. of plasma, or 6 donors daily to provide 120 Gm. protein. The serum protein gain thus effected may be only slight and temporary.

Transfusion aids protein nutrition indirectly, however, by eliminating an early priority for protein synthesis.<sup>17, 18</sup> This permits the utilization of more dietary protein for cell repair, manufacture of immune globulins and other important physiologic functions. In other words, while blood is not included in the nitrogen balance calculation it does help facilitate body protein restoration.

The value of *tube feeding* in surgical patients is well established and satisfactory feeding formulas are generally available.<sup>65, 73</sup> Tube feeding should be used to supplement an inadequate dietary intake or for the entire feeding for those unable or unwilling to eat. Formulas should be prepared fresh daily and refrigerated. Feeding tubes should be changed frequently to prevent bacterial growth and clogging with the formulas. Intolerance such as nausea and diarrhea occasionally result from bacterial contamination or excessive fat in the formula, but it may be a manifestation of malnutrition itself in which it should be controlled by such medications as paregoric and the amount of feeding temporarily reduced. Oral antibiotics when responsible for diarrhea, should be temporarily discontinued.

*Continuous feeding* or frequent, almost hourly feeding 24 hours each day, has advantages where maximal protein utilization is desired. Protein is not stored in the body, hence the continuing requirements of catabolism are met entirely by endogenous sources between fractional feeding. Gains from intermittent day-time feeding may therefore be lost during the night. Since metabolic processes are continuous, the provision of exogenous protein might well be continuous. Anabolic processes may then predominate so long as a protein deficit exists.

The lesser amount of urinary nitrogen that is seen in continuous feeding than is seen in fractional feeding of an identical high protein formula,<sup>61</sup> suggests either a liver or renal threshold for amino acids. Certainly there is a limit to the rate ability of the body's protein synthesizing mechanism, therefore, continuous or frequent day and night feedings are more efficient.

Androgens have been used for their protein anabolic effect with little gain but with unpleasant side effects. Lysine and other amino acids have been supplemented to improve the amino acid pattern especially of plant proteins for improved nitrogen retention. They must be utilized simultaneously with the protein or hydrolysate which is administered or they are deaminated and their nitrogen excreted.

Of all considerations of protein nutrition we believe that the consideration of the metabolic time factor is most important. During protein hydrolysis the amino acids are liberated at varying rates of velocity<sup>45</sup> and they are not retained in the tissue fluids and lymph for longer than an hour<sup>12, 32</sup> so may not be present simultaneous for the almost flash reaction of protein synthesis.<sup>29, 30</sup> Furthermore, the caloric energy necessary for protein synthesis must be simultaneously present.<sup>78</sup> Only hourly or continuous feedings meet these criteria.

Whole protein mixtures such as kitchen formulas and some commercial preparations are too thick for gravity drip and too unstable for prolonged and continued administration. They tend to clog the fine plastic feeding tube and to become toxic from bacterial growth. These objections may be avoided if administered from a thermos bottle by some continuous pump mechanism.<sup>62</sup> If fed intermittently it should be frequent and around the clock.

Protein hydrolysate feeding formulas<sup>35</sup> are thinner and more satisfactory for continuous administration through a fine plastic nasal feeding tube. If stabilized, sterilized and rendered resistant to bacterial growth,<sup>27, 28</sup> they may be stored at room temperature indefinitely without deterioration. Such stable preparations may be given continually for many months if necessary with minimal dietary and nursing care and with satisfactory patient tolerance. They usually contain approximately 65 Gm. amino acids and 900 to 1000 calories principally as carbohydrate and therefore have a high crystalloid content, so may be extremely hypertonic. Large amounts rapidly administered to malnourished patients may pull additional fluid into the intestinal tract and cause liquid stools. Only  $\frac{1}{2}$  to 1 liter should be administered during the first 24 hours, and by a very constantly controlled rate of 8 to 12 drops per minute varying with the administration set used. This may be increased as tolerated by 500 cc. daily until  $1\frac{1}{2}$  to 2 liters or the desired daily intake is reached. One liter in 24 hours or during the night only, may be adequate as supplemental feeding.

Any method of feeding which provides correction of an established protein deficit and maintenance of nitrogen equilibrium is satisfactory. We believe that for maximal protein utilization tube feedings should be more frequently resorted to, either for total or supplemental use. When protein restoration is urgent night fasting should not be permitted. Vitamines, particularly of the B complex group are important in protein synthesis and must be provided. Potassium and phosphorous leave the cells with protein during catabolism and must be pro-

vided along with other intracellular trace elements as part of an adequate formula. Fluid and electrolyte balance must also be restored and maintained if complete restoration is to be achieved.

#### SUMMARY

The early recognition of protein depletion or deficit and an understanding of the mechanisms involved in its development are essential for proper management of this serious complication to disease or injury. Its true significance must be appreciated in order to minimize complications, morbidity and mortality of otherwise successful surgical procedures. The increased nutritional requirements imposed by disease, trauma and major operations must be appreciated and satisfactory methods of attaining maximal protein acceptance and utilization must be understood.

The various reasons for inadequate intake and the methods and routes of protein loss are discussed and their early correction is emphasized. The extra renal losses by transudates, exudates, emesis, diarrhea, intestinal fistulas and of repeated hemorrhage are well known but the magnitude of urinary nitrogen excretion due to "stress" of disease, major burns, fractures and other trauma and of surgical procedures and even prolonged immobilization and bed rest, is not generally appreciated. When this loss is imposed upon an already malnourished patient its correction may be almost impossible and the continuing negative nitrogen balance will lead to body protein depletion with all of its well known complications such as impaired wound healing, edema and ulceration of respiratory and intestinal mucosa, ileus, infections, oliguria, etc.

Chronic shock is a nutritional problem in which the diminished hemoglobin and serum protein results in a diminished blood volume. However, its correction by transfusions alone is not sustained due to protein disequilibrium resulting in the transfused serum protein shifting to the tissues in a 30:1 ratio. These patients require repeated transfusions if surgery is delayed or deferred and postoperatively transfusions should be repeated otherwise acute shock, ileus and oliguria may result. Wherever possible operation should await a period of nutritional restoration of serum proteins for correction of the blood volume deficit and stabilization of body proteins.

Methods of reproteinization of the depleted patient are discussed with particular emphasis on the time factors in protein metabolism and synthesis. It appears that frequent, almost hourly, or continuous around the clock feeding for maximal utilization of protein is acceptable and most effective. The problems of intolerance and rejection of forced nutrition are acknowledged and create a challenge to the thoughtful surgeon.

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## AN EXPERIMENTAL STUDY OF ARFONAD IN HEMORRHAGIC SHOCK IN DOGS\*

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The problem of protection of body economy from the noxious effects of marked hemorrhage has stimulated a number of laboratory investigations in recent years. In the course of these studies, it has been shown that the prophylactic administration of drugs such as Dibenamine and the tetra ethyl ammonium compounds,<sup>2, 10, 15, 16, 17</sup> or of spinal anesthesia<sup>8</sup> will reduce the mortality rate in the group of animals so treated. The effects of the drugs and of spinal anesthesia are alike in the sense that sympathetic responses are effectively blocked in both cases, although the physiologic interruption takes place at different sites in the nerve pathway.

The validity of the philosophy of protection, by means of pretreatment, is open to certain criticism. As mentioned above most investigators in this field are interested in the consequences of body responses to pronounced hemorrhage. It is then necessary, if two sets of experiments are to be compared, that the induced hemorrhages, viewed as deleterious stimuli, be exactly the same, in relation to those factors which will determine its modalities. By this is meant that a ganglionic blocking agent, administered in an effective dose prior to hemorrhage, will alter the amount and rate of bleeding, the rate of hemodilution etc., which are integral parts of the hemorrhagic entity. Therefore the protective, or preventive, action of any given ganglionic blocker can be estimated only if the drug is administered *after* the hemorrhage has taken place, and before changes which are irreversible and incompatible with life, have become established.

It is for this reason that fractional bleeding, using the volumetric technic,<sup>6</sup> or the more conventional pressure bottle technic,<sup>21</sup> are quite unsuitable for this type of investigation. In the former case it is practically impossible to say when the necessary "*total stimulus*" has been administered, and when irreversible changes have taken place. It is clear that as soon as the blocking drug is given, the response to further hemorrhage will be modified. Thus if the drug is given prior to the total stimulus-hemorrhage, a change in mortality rate would be quite meaningless. If, however, one waits long enough for irreversible changes to have become established, then the administration of the drug becomes meaningless.

The disadvantages of the pressure bottle technic for this type of investigation are quite obvious. As long as the flow between the vascular bed and the bottle is unobstructed, fluids will shift according to pressure gradients. The administration of a ganglionic blocker results in a change in pressure and a consequent change in gradient, permitting some of the blood to return from the collection

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bottle to the animal. Thus an important, nonmeasurable factor, alters the stimulus-response pattern.

In studying the effects of a ganglionic blocker (Arfonad®) on the response of dogs to experimentally produced hemorrhage, we have therefore utilized a method of inducing hemorrhagic shock which depends solely upon a single stimulus, quite circumscribed in time, and of such a nature that if untreated, results in death in 100 percent of animals thus "shocked". The method is that which was first investigated by Walcott,<sup>19</sup> since it was felt that it completely eliminated the patent objections to the previously mentioned methods.

#### METHOD

Unselected mongrel dogs, weighing from 9 to 29 Kg., were used. Analgesia was induced by intravenous administration of Nembutal sodium® 60 mg./Kg. Endotracheal intubation was performed and the dog allowed to breathe room air. The femoral vein and artery of one side were exposed. The artery was cannulated and attached to a conventional, damped, mercury manometer. An 18 gauge needle, with an attached three-way stopcock, was inserted in the vein. One arm of the stopcock was utilized as a portal for the administration of a saline infusion. All blood samples were withdrawn from the vein in the following fashion; first the saline flow was interrupted, 2 ml. of blood were aspirated and discarded, and then utilizing a fresh syringe, the appropriate sample was withdrawn.

In the set of experiments where hemorrhage was induced, the femoral artery of the opposite side was exposed. A polyethylene cannula with an inside bore of 3.17 mm. was inserted. This cannula was attached to a short length of Venotube®, the other end of which was attached to a three-way stopcock. The system was filled, before cannulation, with a Heparin solution (10 mg./cc.).\* Immediately after cannulation, blood was gently aspirated into a series of 50 cc. syringes, previously rinsed with heparin. After withdrawal of 300 to 400 ml. of blood the stopcock was removed, and free flow was allowed into a calibrated burette, from the open end of the Venotube®, maintained at the level of the right atrium. Bleeding was discontinued after free flow had ceased, and respiration disappeared. Within 1 minute reinjection of 25 percent of the shed blood was begun and was usually complete in about 2 minutes. The same artery which had been used for bleeding was used for reinfusion. In all cases respiration resumed after reinfusion of blood, although occasionally the apnea lasted up to 3 minutes.

After reinfusion, Arfonad®, in isotonic saline (0.1 mg./ml.), was administered via an intravenous drip. The rate of infusion was adjusted so that ganglionic blockade, as demonstrated by pupillary dilatation, was obtained. No attempts were made to maintain the blood pressure at any specific level. At the end of 5 hours the Arfonad drip was discontinued. No blood or plasma expanders were administered to the animals at any time. The animals which did not receive Arfonad® received estimated equal amounts of isotonic saline. At half hourly intervals 4 ml. samples of venous blood were removed for various studies.

All blood volume determinations were made by tagging the red cells with

\* Graciously supplied by Eli Lilly Company, Indianapolis, Indiana.

radiochromate 51. A modification of previously reported technics<sup>1, 12</sup> was used; approximately 35-45 ml. of blood were withdrawn in specially calibrated, heparinized, syringes (MacAlaster-Bicknell-Cat. no. M.B.-670) and approximately 30 Microcurie of Radiochromate 51 were immediately added to it. This mixture was allowed to incubate at room temperature for 45 minutes, with occasional gentle shaking. At the end of this period 50 mg. of ascorbic acid were added. After two minutes a 4 ml. sample was withdrawn from the syringe. This sample was placed in a hematocrit tube of the Sanford-Magath type. The remaining blood was freed of air bubbles and an accurately measured amount injected into the dog. The first sample was taken from the dog 20 minutes later and additional samples at selected intervals. All samples were of 4 ml. volume, were all withdrawn following the technic described above, and were all put in the same type of hematocrit tube. All samples were centrifuged at the same time for 30 minutes at 3000 rpm. The plasma was subsequently aspirated with a pipette connected to a trap bottle. Geiger counting was done on the packed red cells placed in the well of the scintillation detector. All counts were reduced to 1 minute figures after correction for background activity.

Calculations were then made of the absolute red cell volume. The absolute packed cell volume which had been injected was calculated from the hematocrit reading of the sample taken from the syringe. From this figure the total injected counts were calculated using the formula

$$Q_2 = \frac{Q_1 \cdot V_2}{V_1}$$

where  $Q_1$  = corrected counts on sample from injected blood

$V_1$  = red cell volume of sample from injected blood

$V_2$  = computed total red cell volume that was injected

$Q_2$  = total of unjected counts

This number ( $Q_2$ ) was used as a reference for all subsequent red cell volume determinations, for which the following formula was used:

$$M = \frac{m \cdot C}{c}$$

where  $C$  = total of injected counts

$m$  = absolute packed red cell volume in sample being examined

$c$  = corrected count on sample  $m$

$M$  = total red cell volume

The total blood volume was determined from the known value of the hematocrit of each individual sample.

#### RESULTS

Two series of experiments were carried out. Each series consisted of 10 splenectomized dogs. Each group of dogs was bled according to the technic described under "methods". One group received intravenous Arfonad®, 0.1 mg./ml in iso-

TABLE 1

Summary of blood loss values in treated and untreated animals: values are expressed in ml/kg body weight

Explanation in text

	BLEEDING VOLUME			TOTAL BLOOD LOSS		
	RANGE	MEDIAN	MEAN	RANGE	MEDIAN	MEAN
TREATED	52 — 81	58	62	42 — 66	47	52
UNTREATED	45 — 76	63	61	37 — 68	49	51

TABLE 2

Comparison of survival rate and survival time in treated and untreated dogs

	DEAD	ALIVE	TOTAL
TREATED	6	4	10
UNTREATED	10	0	10

MAXIMAL SURVIVAL TIME  
UNTREATED GROUP

tonic saline, while the other received an estimated equal amount of normal saline.

The amount of blood which was subtracted from the animals in either group is summarized in table 1. The bleeding volume is defined as the amount of blood which can be shed with the initial maximal bleeding. Its relationship to body weight, blood volume and the like is unpredictable.<sup>14</sup> However since it represents the maximal hemorrhagic insult that the particular animal can permit, it is assumed to represent a constant factor i.e. a maximum common denominator. The total blood loss is defined as the adjusted loss after allowances for 25 percent reinfusion and subsequent blood loss through sampling (as described under "methods", blood samples were withdrawn at 30 minute intervals).

Attention is called to the close agreement between the groups of figures for bleeding volume and total loss. However when the survival rate, and survival time, for the two series are compared, a striking difference is observed (table 2). All of the animals in the untreated group were dead at the end of 5 hours and 55

minutes. This time limit is in close agreement with the figures published by Walcott.<sup>19</sup> In the treated group 4 dogs were still alive at the end of this time interval. Two of these 4 dogs died at the end of 13 and 16 hours respectively. Autopsies were performed on these animals, and in both, a diagnosis of acute pulmonary edema was returned by the pathologist. The remaining 2 dogs lived indefinitely, and at the end of 3 weeks were considered fully recovered.

The use of splenectomized animals was indicated because the results of our pilot study on the effects of Arfonad® alone on blood volume supported the reports in the current literature outlining the relative unreliability of blood volume determinations in nonsplenectomized dogs.<sup>13</sup> The above-mentioned pilot study data is briefly summarized. A series of paired experiments were carried out in intact and splenectomized dogs. After cannulation of the femoral artery for blood pressure recording, blood samples were withdrawn for total red cell volume and hematocrit control determinations in the same manner as mentioned previously. Arfonad®, 0.1 mg./ml in isotonic saline, was then administered via an intravenous drip and continued for a 2 hour period. Total red cell volume and hematocrit determinations were repeated at 30 minute intervals. In table 3 the range of variability of these two values is expressed as percentage of the initial control values, while figure 1 depicts the chronologic appearance of these variations. It was our experience that in the intact animal the administration of Arfonad® resulted in the release of large numbers of untagged red cells from a reservoir, thus seriously complicating blood volume calculations. The absence of this phenomenon after splenectomy is a reasonable indication that this organ is the affected reservoir. The reason for this response on the part of the spleen to the administration of Arfonad® is not quite clear. It may be due to a direct effect of the drug on the spleen, or it may be secondary to the low blood pressure sec-

TABLE 3

*Range of variability in total red cell volume and hematocrit in intact<sup>10</sup> and splenectomized<sup>10</sup> animals, expressed as percentages of original control value considered as 100 per cent*

	TOTAL RED CELL VOLUME (RANGE)	HEMATOCRIT (RANGE)
INTACT	100 — 137	100 — 138
SPLEEN OUT	95 — 104	87 — 103



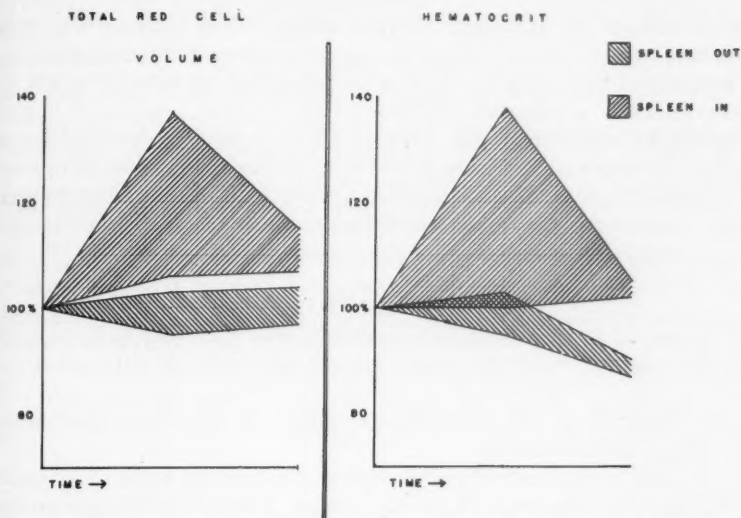


FIG. 1. Chronologic appearance of variations in red cell volume and hematocrit in intact and splenectomized animals. Explanation in text.

ondary to its administration. However it is quite obvious that if Arfonad® had a specific effect on the spleen of a dog, in the sense that it would facilitate the release of red cells from this organ, the results of its administration to a bled animal, in terms of survival rate, might be quite difficult to interpret.

#### DISCUSSION

The concept of irreversibility as it applies to hemorrhagic "shock", in both man and the experimental animal, is easier of description than of real definition. Common usage implies that irreversibility occurs in hemorrhagic shock at the time, following the initiation of bleeding, when reinfusion of the shed blood fails to alter the inexorable pattern of deterioration and death of the subject.<sup>20, 21</sup> The fact that reinfusion of all shed blood fails to convert the organism to its normal state indicates that hypovolemia itself is not the sole cause of the "irreversible state". Because generalized vasoconstriction is an immediate response to blood loss of any magnitude, it has been indicted as a physiologic response which, if prolonged, becomes a pathophysiologic parent mechanism resulting in irreversibility and death.<sup>3, 11</sup> The fact that prolonged intravenous administration of adrenalin-like substances, producing persistent intense vasoconstriction, can result in a similar state of irreversible shock,<sup>7, 9</sup> appears to establish vasoconstriction as the modality towards which therapeutic efforts should be directed.

The pooling and trapping of blood in the peripheral vascular bed,<sup>22</sup> and the anoxic metabolism which of necessity results,<sup>18</sup> appear to be more intermediate results than actual etiologic factors amenable to direct attack. Since the irreversible phase of shock appears to be due primarily to a specific bodily response,

mediated through the autonomic nervous system, which response has subsequently become a pathologic agent, it has appeared logical to obtund this response with ganglionic blocking agents, both in the laboratory, as reported herein, and in clinical practice as reported elsewhere.<sup>4, 5</sup>

Although we have been unable to quantitate accurately the exact parameters within which ganglionic blockade prevents, or prolongs, the onset of irreversibility in hemorrhagic shock, the alteration in survival rate in the treated animals suggests very strongly that ganglionic blockers such as Arfonad® should be given extensive trial in the management of clinical hemorrhagic shock.

#### SUMMARY

Two series, of 10 splenectomized dogs each, were subjected to hemorrhagic shock, utilizing the Walcott bleeding technic which results in 100 percent mortality.

In the untreated control series, all the animals died, the longest survival time being 5 hours and 55 minutes.

The animals in the treated series received a ganglionic blocker (Arfonad®), immediately after completion of the hemorrhage. Four of the 10 dogs survived more than twice the maximum survival time of the control series. Two of these 4 dogs went on to permanent survival.

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## THE CONTRIBUTION OF SIMULTANEOUS RIGHT AND LEFT HEART CATHETERIZATION IN THE SURGICAL EVALUATION OF MITRAL VALVE DISEASE

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The past decade has seen the development of a rational and clinically successful therapeutic approach to the problem of mitral stenosis. Direct preoperative physiologic documentation of the stenotic lesion and objective postoperative mensuration of the physiologic end result of the valvular surgery were not possible prior to the advent of left heart catheterization. Although right heart catheterization has been of unquestioned value, the efficacy of this procedure alone is limited because of the difficulty in separating the effects of mechanical valve block from those of pulmonary vascular disease and myocardial insufficiency (the myocardial factor).

Recognition of the limitations of right heart catheterization led to the development of methods permitting direct measurement of left atrial and left ventricular dynamics. These methods include transbronchial, suprasternal and posterior percutaneous approaches.<sup>1-4, 7, 8</sup> A modification of the Fisher percutaneous technic has been employed in the studies reported herein.

In the normal subject left atrial and left ventricular pressures are virtually identical in diastole as are left ventricular and central aortic pressures during systole. The existence of a left atrial-left ventricular diastolic pressure difference or a left ventricular-aortic systolic pressure difference is indicative of mechanical obstruction of the mitral or aortic valves respectively. This pressure differential across either valve is defined as a gradient. Mean gradient is a planimetrically determined average gradient in either diastole or systole.

The magnitude of the mean diastolic left atrial-left ventricular gradient is not only dependent upon the severity of the stenosis but also upon the parameters of flow across the valve and diastolic filling time (the latter obviously a function of cardiac rate). Thus, just as the limitations of right heart catheterization are apparent, it is clear that left heart catheterization performed alone fails to define the contribution of variation in flow per unit time to the measured atrio-ventricular diastolic gradient. In order to properly evaluate the physiologic derangement in these patients, it is necessary that a simultaneously performed *combined*

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right and left heart catheterization be done. Cardiac output (flow across the valve) is determined by the right heart catheterization utilizing the Fick method; The diastolic atrio-ventricular gradient is determined by the left heart catheterization.

To date, 40 simultaneous combined right and left heart catheterization studies have been performed and constitute the basis for this report.

#### METHODS

Right heart catheterization is performed in the usual manner in the supine position in the basal postabsorptive state. Multiple steady state pressure and cardiac output determinations by the Fick method are made at rest, during exercise and recovery. With the right heart catheter and brachial artery needle in situ, the patient is turned into the prone position. Meperidine hydrochloride, 50 to 100 mg., is subsequently given intramuscularly.

Left heart catheterization is performed via a modification of the posterior percutaneous puncture technic of Fisher.<sup>4</sup> Fluoroscopic visualization of the left atrium is carried out with the patient in the prone position and left atrial puncture accomplished by passage of two 7 or 8 inch No. 17 thin walled styletted needles. Polyethylene tubing is passed through these needles into the left atrium and left ventricle. Simultaneous pressures are then obtained (from the same baseline and at identical or similar strain gauge sensitivities) from the left atrium, left ventricle and brachial artery. In recent studies, simultaneous pressures have been obtained from left atrium, left ventricle, pulmonary artery and right ventricle, the former group using Statham P 23 D strain gauges and the latter with Statham P 23 AA strain gauges. A six channel cathode ray photographic recorder\* has been utilized in these studies.

In 10 patients, the left heart needles have been removed with the polyethylene catheters remaining in situ. The patient is then turned back into the supine position and simultaneous pressure studies recorded from the left atrium, left ventricle, pulmonary artery and right ventricle at rest, during exercise and on recovery. It has been found that repeat steady state Fick cardiac output determinations at rest and during exercise is feasible during these latter pressure determinations.

#### MATERIAL

Forty simultaneous combined heart catheterizations have been performed in 34 subjects—19 men and 15 women.

Twelve studies have been performed in 11 female patients during the course of evaluation for possible mitral commissurotomy. Two of these 11 patients were recatheterized 1 month postoperatively. Four other women were catheterized at varying intervals after commissurotomies performed elsewhere.

Sixteen male patients were investigated by combined heart catheterization during evaluation for possible mitral and/or aortic commissurotomy. Three of

\* Electronics for Medicine, Inc., White Plains, New York.



these subjects have been restudied after mitral commissurotomy. Three other men had combined heart catheterization during the course of study for heart disease of nonrheumatic origin.

Over-all, 14 women and 16 men had rheumatic heart disease with mitral and/or aortic valve disease. The ages of the 34 subjects ranged from 18 to 59 years.

#### RESULTS

*I. Cardiac Output Data:* Multiple cardiac output data in a 49 year old white man are presented in table I to demonstrate that steady state cardiac output measurements both at rest and on exercise can be performed while the patient is in the supine position with both right and left heart catheters in situ (table I). The first 3 outputs were obtained at rest in the supine position with the right heart catheter in place. Outputs 4 and 5 were obtained during exercise under the

TABLE I

Output Number	Cardiac Index (l./min./M <sup>2</sup> B.S.A.)	Oxygen Consumption (ml./min./M <sup>2</sup> B.S.A.)	A-V Difference (vol. %)	R
1	1.85	126	6.8	.77
2	1.75	123	7.0	.81
3	1.69	120	7.1	.83
4	2.23	244	10.9	.87 (exercise)
5	2.22	235	10.6	.89 (exercise)
6	1.78	115	6.5	.85
7	1.95	224	11.5	.99

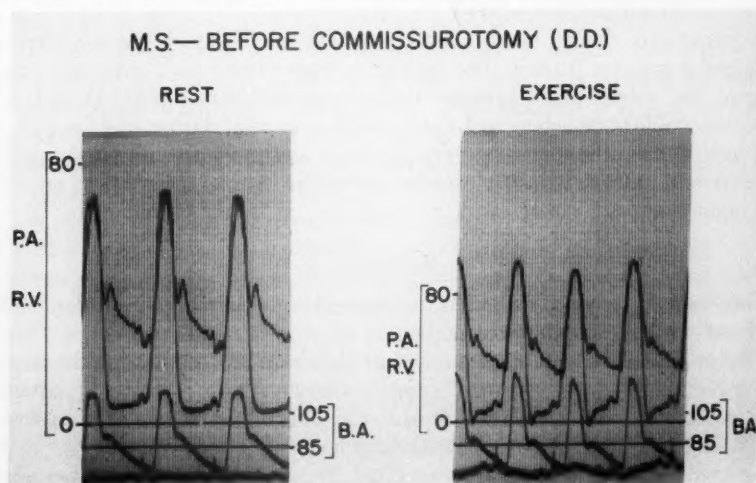


FIG. 1. Right heart catheterization data with surgically proved tight mitral stenosis. There is marked pulmonary hypertension at rest with a further rise during exercise. Paper speed is 25 mm./sec.

same conditions. The sixth output was determined in the supine position after placement of the left heart catheters. The last output was obtained during exercise with both left and right heart catheters in place. The average cardiac index at rest is 1.76 l./min./m<sup>2</sup> and 1.78 l./min./m<sup>2</sup> during the right and combined heart catheterizations respectively. The corresponding data for oxygen uptake

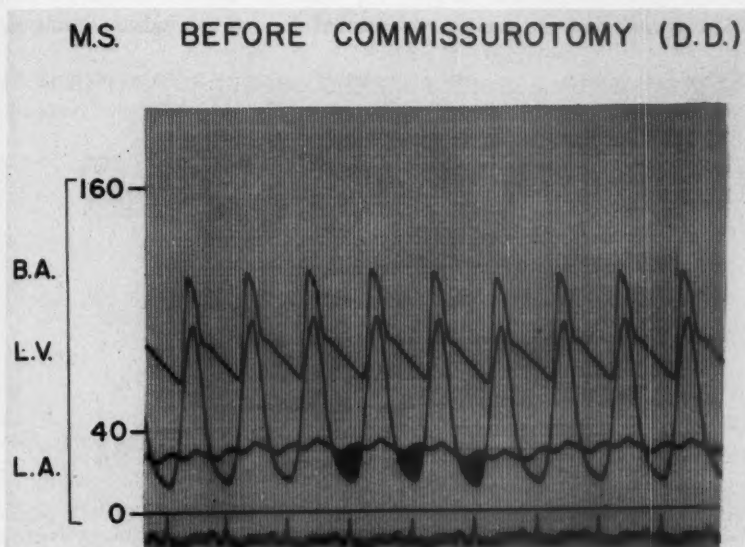


FIG. 2. Left heart catheterization data in the same subject. The blackened areas represent the mean diastolic left atrial-left ventricular gradient, 12 mm. Hg.

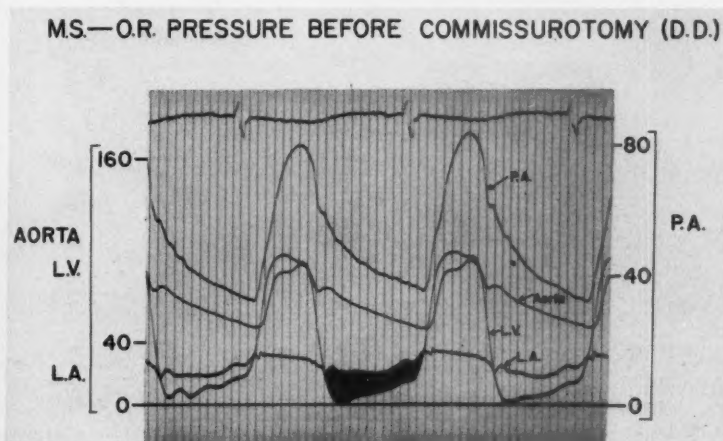


FIG. 3. Operating room precommissurotomy left and right heart pressure curves. The mean diastolic gradient is 14 mm. Hg. Paper speed is 75 mm./sec.

are 123 ml./min./m<sup>2</sup> and 115 ml./min./m<sup>2</sup>. The corresponding arteriovenous differences are 6.9 vol. % and 6.5 vol. % respectively. The average R (respiratory quotient) is 0.81 at rest during right heart catheterization and 0.85 during the combined procedure. The steady state criteria for cardiac output determinations advanced by Fishman and associates<sup>5</sup> are thereby met.

Similarly, the exercise data (obtained by pedaling a bicycle wheel in the supine position) reveal close correspondence between the cardiac indices during right

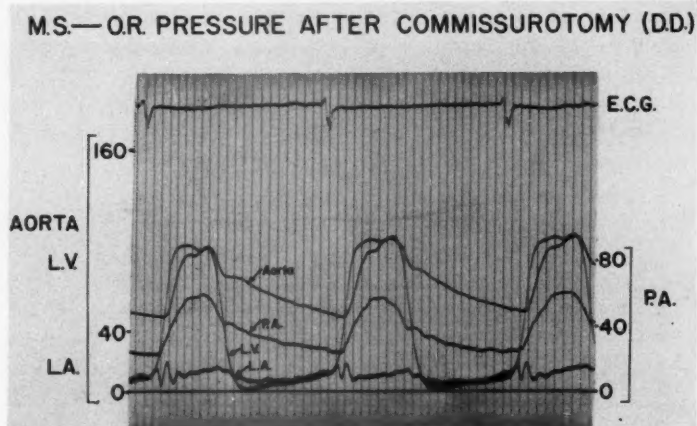


FIG. 4. Operating room postcommissurotomy left and right heart pressure curves in the same patient. The mean gradient is 1 mm. Hg.

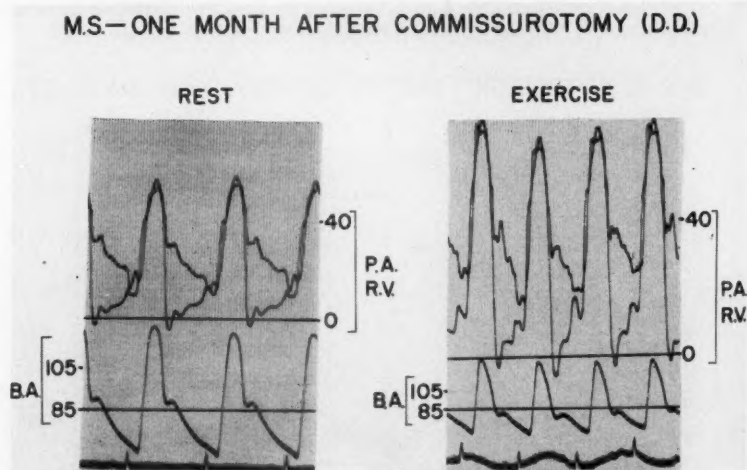


FIG. 5. Right heart catheterization data in the same individual 1 month after commissurotomy. There has been a fall in pulmonary artery pressure at rest and on exercise (compared to preoperative values) but significant pulmonary hypertension still exists both at rest and on exercise.

and during simultaneous combined right and left heart catheterizations respectively. The slightly lower cardiac index during the combined catheterization is related to the somewhat lower oxygen consumption at this time.

Similar data have been collected in 7 other patients in whom it has been possible to obtain such measurements in the supine position during both rest and exercise in the course of combined right and left heart catheterizations. The feasibility of similar steady state cardiac output measurements in the prone position, as advocated by some investigators, remains to be evaluated.

**II Pressure Data:** Two basic physiologic patterns have been observed. The first consists of significant pulmonary arterial hypertension at rest or on exercise

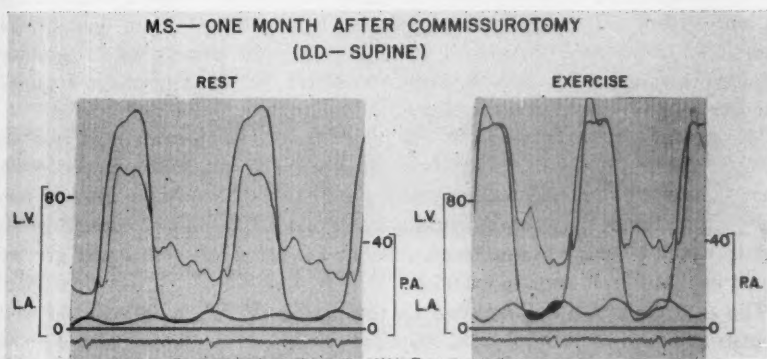


Fig. 6. Left heart catheterization data in the same individual 1 month after surgery. The atrio-ventricular gradient is 1 mm. Hg and 4 mm. Hg at rest and during exercise respectively.

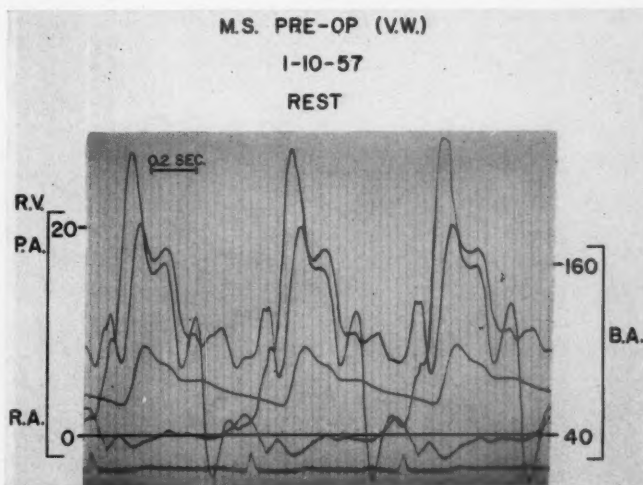


Fig. 7. Right heart catheterization data in a 38 year old woman. There is no pulmonary hypertension at rest. Note the "fing" on the right ventricular curve.

and a significant mean diastolic left atrial-left ventricular gradient at rest or on exercise. The former has been arbitrarily defined as a systolic pressure in the pulmonary artery or right ventricle of at least 35 mm. Hg, recognizing that the upper limit of normal is approximately 30 mm. Hg. The latter has been arbitrarily defined as a mean gradient of at least 5 mm. Hg. The second pattern is characterized by the absence of significant pulmonary arterial hypertension at rest or on exercise in the presence of a significant mean diastolic left atrial-left ventricular gradient.

Figures 1 through 6 illustrate the first pattern in D. D., a 40 year old man with surgically proved tight mitral stenosis. Figure 1 illustrates the marked pulmonary artery hypertension which is further increased on exercise. Figure 2 demonstrates the presence of left arterial hypertension and a significant mean diastolic left atrial-left ventricular gradient. Figure 3 reveals the same diastolic gradient obtained at surgery. The immediate postoperative tracings are seen in Figure 4. The gradient has been almost completely obliterated.

The right heart catheterization findings 1 month postoperative at rest and during exercise (fig. 5) reveal residual but decreased pulmonary hypertension. That this residual pulmonary hypertension is not related to an inadequate commissurotomy is demonstrated by the postoperative left heart catheterization (fig. 6) which reveals a 1 mm. mean diastolic left atrial-left ventricular gradient which increases to 4 mm. on exercise.

The second pattern is illustrated by the data in V. W., a 38 year old white woman in whom significant pulmonary arterial hypertension, as defined above, was absent both at rest and on exercise (figs. 7, 8). The resting mean diastolic left atrial-left ventricular gradient is 5 mm. Hg (fig. 9). During a bout of spon-

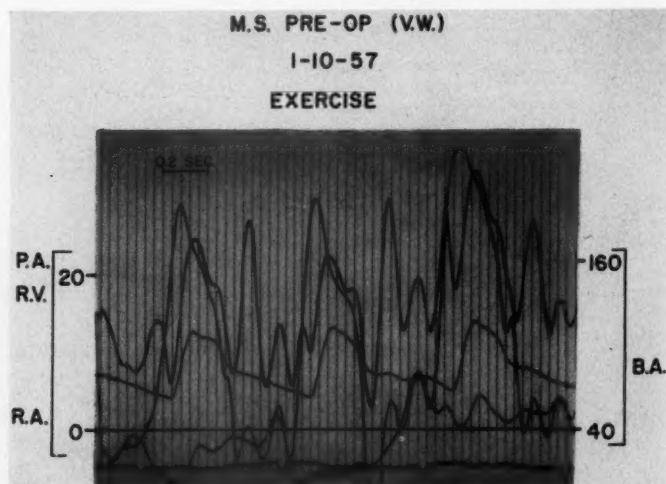


FIG. 8. Right heart catheterization data on exercise in the same patient. Significant pulmonary hypertension is absent.



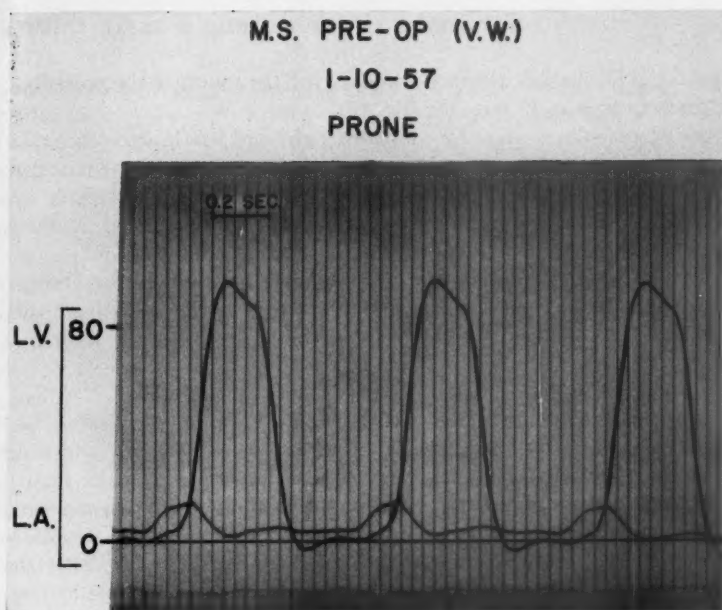


FIG. 9. Left heart catheterization data in the same individual at rest. The mean gradient is 5 mm. Hg. Ventricular rate is 79 per minute.

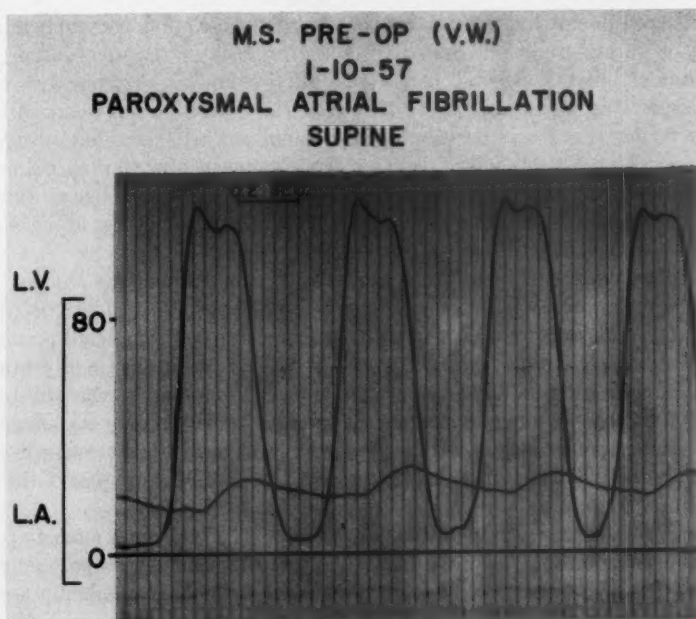


FIG. 10. Left heart catheterization data in the same patient during a bout of spontaneous atrial fibrillation. The mean diastolic gradient has risen to 13 mm. Hg with a ventricular rate of 113 per minute.

aneous atrial fibrillation which occurred during the course of the procedure, the mean gradient rose to 13 mm. Hg (fig. 10).

Of the 34 patients studied by combined right and left heart catheterization, 23 patients had mitral stenosis (with significant left atrial-left ventricular gradients as defined above) with or without other associated valvular lesions. Twenty-one of these 23 were studied preliminary to possible mitral commissurotomy; 2 were studied postoperatively.

Twenty of the 21 patients in the evaluation group exhibited the first pattern described above and 1 patient demonstrated the second pattern. Both patterns were observed in the 2 postoperative patients.

#### DISCUSSION

Despite the fact that left heart catheterization is still in its infancy, the data obtained from this procedure during the course of combined simultaneous right and left heart catheterization has been of such import as to make right heart catheterization alone of limited value in the evaluation of patients with left sided rheumatic valvular heart lesions. The severity of the mitral stenotic lesion is susceptible to direct analysis when data as to the mean diastolic left atrial-left ventricular gradient, cardiac output and heart rate are available at rest and during exercise. The demonstration that a steady state can be achieved during left heart catheterization both at rest and exercise (table I) is therefore of considerable importance.

It has been postulated that the absence of significant pulmonary hypertension at rest or during exercise is evidence for the primacy of the myocardial factor over that of mitral valve block and that such a finding suggests that mitral commissurotomy is not indicated.<sup>6</sup> However, the data from left heart catheterization render this thesis untenable since significant left atrial-left ventricular mean diastolic gradients have been found in the absence of marked pulmonary hypertension even during exercise. Furthermore, in 4 instances significant left atrial-left ventricular mean diastolic gradients were found in the absence of an elevation in the so-called pulmonary "*capillary pressure*".

Two physiologic patterns have emerged to date in the patients studied, all of whom were symptomatic. In both groups a significant left atrial-left ventricular diastolic gradient was found but in only the first group was significant pulmonary hypertension noted at rest or during exercise. A third pattern has been postulated but no examples thereof have as yet been noted. Theoretically, this third group is one of absent significant pulmonary hypertension and absent significant left atrial-left ventricular mean diastolic gradient at rest and during exercise in symptomatic patients. This group would represent the classical examples of the myocardial factor.<sup>6</sup>

One patient with severe pulmonary hypertension of unknown etiology proved to be of great interest. The patient was a 35 year old white female who presented herself with severe exertional dyspnea, syncopal episodes, a markedly accentuated second pulmonic sound, and an apical diastolic rumble. On right heart catheterization, marked pulmonary hypertension was evident (fig. 11). However,

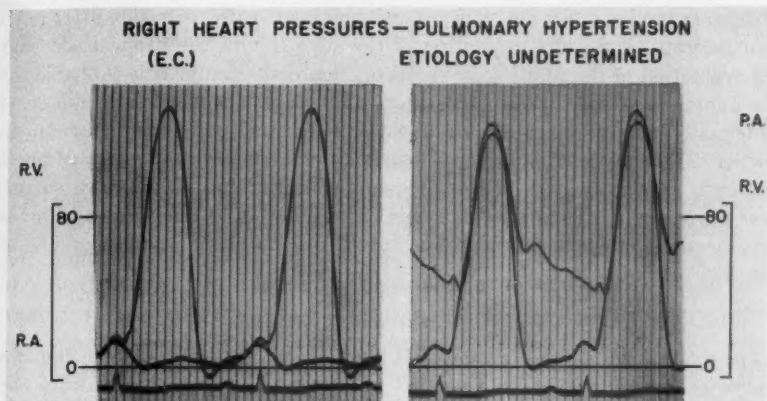


FIG. 11. Right heart catheterization data in E. C., a 35 year old woman. The systolic pressure in the pulmonary artery is 132 mm. Hg.

**LEFT HEART PRESSURES—PULMONARY HYPERTENSION  
(E.C.) PRONE ETIOLOGY UNDETERMINED**

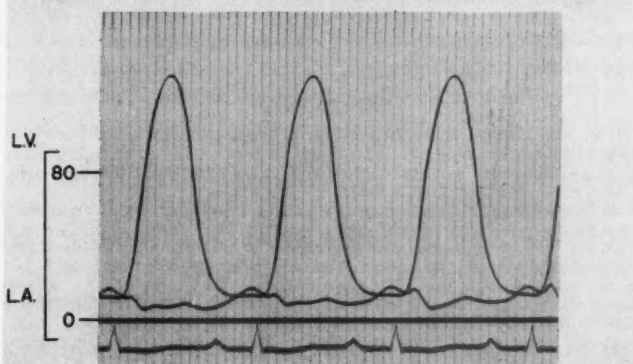


FIG. 12. Left heart catheterization in the same patient. There is no diastolic atrio-ventricular gradient.

on left heart catheterization no left atrial-left ventricular gradient was demonstrated (fig. 12). Surgery was not advised. The patient subsequently died and no evidence of mitral stenosis was found at necropsy.

Two further points should be stressed again. First, left heart catheterization alone is of limited value in evaluating stenotic lesions of the mitral and aortic valves since the resultant gradients are materially influenced by variations in flow across the valve. Thus, simultaneously performed left and right heart catheterization is necessary to assess the true physiologic significance of the valvular obstruction. Right heart catheterization permits determination of cardiac output or flow across the valve (in the absence of dynamic mitral insufficiency); left heart catheterization permits determination of the mean diastolic left atrial-left

ventricular gradient. Second, repeat combined heart catheterization after mitral commissurotomy permits evaluation of the adequacy of the surgical procedure and evaluation of the physiologic result of commissurotomy. It is probable that this approach will delineate those poor surgical results which are due to (1) inadequate valve mobilization at surgery, (2) residual pulmonary vascular disease, or (3) the myocardial factor. Thus, it provides an accurate means of intelligent long term evaluation of the adequacy of mitral and aortic valve surgery. Over the years, it should provide a most valuable tool in establishing a physiologic means of prognosis in rheumatic valvular disease both in operated and unoperated patients.

#### SUMMARY

The limitations of either right or left heart catheterizations alone in the selection of patients for mitral and aortic surgery are discussed. Simultaneous combined right and left heart catheterization permits more accurate physiologic definition of stenotic lesions of the mitral or aortic valve in terms of both gradient and flow. Use of this modality in evaluating poor surgical results will be of value in defining those cases resulting from inadequate commissurotomy as opposed to those due to residual pulmonary vascular disease or the myocardial factor.

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## EFFECT OF DIVISION OF THE HYPOPHYSEAL STALK IN THE HYPERTENSIVE PATIENT

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The role of the neurohypophysis in the regulation of blood pressure has never been adequately worked out. Cushing<sup>1</sup> suggested many times in his writings that the hypophysis might be an important factor in blood pressure regulation. Page and Sweet<sup>2</sup> in 1937 showed that hypophysectomy performed on dogs, made hypertensive by constriction of the renal artery, produced a marked reduction in the blood pressure level. However, further constriction of the renal artery caused the blood pressure level to rise, but this rise was poorly sustained. When the anterior lobe of the pituitary is removed, the reduction in blood pressure is thought to be due to the loss of adrenocorticotrophic hormone of the anterior lobe. The influence of the pars nervosa on blood pressure regulation has always been a matter of controversy.

In 1940 Rasmussen and Gardner<sup>3</sup> reported a case in which the pituitary stalk was divided and the upper portion of the anterior lobe of the pituitary cauterized in a patient with severe hypertension. They were primarily interested in the effect of division of the pituitary stalk on hypertension but had been advised by an endocrinologist to cauterize the anterior lobe of the pituitary to decrease the production of thyrotrophic hormone and thereby prevent the appearance of polyuria and polydipsia. This was based on the work of Mahoney and Sheehan<sup>4</sup> and the work of Keller,<sup>5</sup> who had shown that diabetes insipidus could be cured by thyroidectomy or removal of the anterior lobe of the pituitary. Dr. Gardner's patient was a 46 year old man who had suffered from headaches for 3 years, had choked disks, and hypertension. A brain tumor was suspected but the ventriculogram was normal. A bitemporal decompression brought relief for 8 months but then the blood pressure rose to 200/130 with recurrence of symptoms and signs of a left frontal lesion. A left frontal craniotomy revealed no tumor; so in order to observe the effect on hypertension, the hypophyseal stalk was brought into view and divided just above the diaphragm of the sella with the electro-surgical unit. At the same time the upper surface of the anterior lobe was cauterized. Immediately after the operation the blood pressure was 110/75. Several weeks later, on removal to a sanitarium, his blood pressure was 124/94. At no time did he show any unusual thirst or polyuria. Five months later he died of a stroke. Histologic examination showed there had been almost a complete division of the stalk and over one-half of the anterior lobe had atrophied. Because of these severe changes in the anterior lobe, one wonders whether the fall in blood pressure was due to division of the pituitary stalk or to reduced activity of the anterior lobe. I was encouraged by Dr. Gardner to undertake a study in which the pitui-

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tary stalk alone was divided. I was able to find very little information regarding division of the pituitary stalk in human beings. In 1940 Dandy<sup>2</sup> reported the case of a girl on whom he operated for blindness of the left eye. No tumor was found. The pituitary stalk was well exposed after resection of the left optic nerve, and to observe its effect the stalk was divided in its midportion. Eleven years later this patient still had diabetes insipidus. She had had two normal pregnancies; lactation had been normal. Menses were regular for several years and then became irregular. There was no change in blood pressure, no loss of hair, and no sugar in the urine.

Dr. Bronson Ray<sup>9</sup> informed me that he once divided the pituitary stalk in a patient with epilepsy in hopes of changing the water balance and thus prevent the occurrence of fits. This patient also had permanent diabetes insipidus.

Dr. Henry A. Shenkin<sup>7</sup> wrote me that several years ago he had divided the pituitary stalk in a patient with malignant hypertension and poor kidney function. The blood pressure preoperative was 300/200. During the 6 days that she survived postoperative her blood pressure was 130-120/80. With the fall in blood pressure her kidneys shut down completely and she died from uremic poisoning.

Sattler and Ingram<sup>10</sup> divided the hypophyseal stalk high through the median eminence of the hypothalamus in 8 dogs made hypertensive by constriction of the renal artery and obtained significant fall in blood pressure in 5 of the 8 dogs. All of these dogs developed polyuria. The administration of pitressin tannate in oil controlled the polyuria but failed to raise the blood pressure significantly.

Because of the meager information available on the effects of division of the hypophyseal stalk in human beings, the cases of 5 patients in whom the stalk was divided to observe the effect on hypertension, and who have been followed from 1 to 5½ years, are reported.

Case 1. L. E. This 53 year old accountant was admitted to the Veterans Administration Hospital in Coral Gables, Florida, on March 8, 1949, in cardiac failure due to hypertensive cardiovascular disease. He had known that his blood pressure had been high for 15 years. Eight years previously he had had a thyroidectomy because of "nervousness" and at that time his systolic pressure was over 200. Four years previously he had developed swelling of his ankles and shortness of breath, and since that time he had been on digitalis. One year before admission he had developed pulmonary edema and was hospitalized for several weeks. The present admission was necessary because of progressive weakness and shortness of breath in spite of digitalis, mercurials, and salt-free diet.

Examination revealed a slightly obese white man appearing older than the stated age of 53. The neck veins were distended. The fundi showed severe spasm of the arterioles. The blood pressure was 230/140. The heart was enlarged and had a gallop rhythm. The liver was enlarged 5 fingerbreadths below the costal margin. The electrocardiogram showed left ventricular hypertrophy and the roentgenogram of the chest revealed an enlarged heart of hypertensive configuration. The intravenous pyelogram was normal. The urine had a specific gravity of 1.020 and showed a trace of albumen. Phenolsulfonephthalein was 25 per cent in the first 15 minutes and the blood urea nitrogen was 17 mg. per cent on one occasion and 15 mg. per cent on another. The blood sugar was 106 mg. per cent. On sodium amytal test the blood pressure came down to 132/70 at one point. With intravenous etamon chloride the blood pressure fell to 140/100. The histamine test did not indicate the presence of a pheochromocytoma. The patient did not improve greatly on a medical regime.

A thoracodorsal sympathectomy was considered but was decided against because the

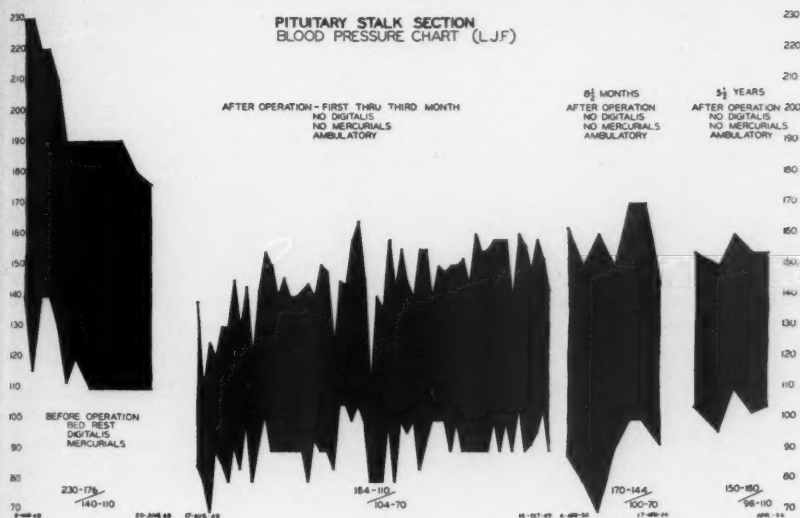


Fig. 1

patient was such a poor operative risk. The patient was anxious that something be done and the division of the hypophyseal stalk was suggested. The patient was agreeable and he was transferred to Jackson Memorial Hospital for this procedure. The operation was done on July 29, 1949, through a right frontal craniotomy. It was necessary to retract the right optic nerve to obtain visualization under the optic chiasm and bring the hypophyseal stalk in view. (This resulted in severe loss of vision in the right eye.) The stalk was divided with special scissors just as it came through the diaphragm of the sella. The postoperative course was satisfactory. There was no increased thirst or polyuria. The blood pressure gradually fell and when transferred back to the Veterans Administration Hospital approximately 3 weeks after operation, it was 138/86 (fig. 1). Five and a half years after operation his blood pressure has remained significantly lower than the preoperative level. Preoperatively the blood pressure range was 230-176/140-110. Five and one half years postoperative the blood pressure range was 160-150/110-96. He has been without digitalis and mercurials since 1 month after operation. For 6 months or so he was on a low salt diet but for the past 5 years he has been on no special diet. He is working as an accountant and getting along well in spite of severely impaired vision in the right eye. There has been no loss of sexual function although on his last follow-up admission there was some sparsity of pubic hair and slight enlargement of the breasts.

Case 2. J. H. This 55 year old white woman was sent to me because of progressive weakness, headaches, increasing fatigability and apathy. She was known to have hypertension of several years duration and was also known to have kidney disease. Occasionally she had complained of pain around her heart. She had never been in cardiac failure. She had been treated with sedation and the rice diet. She had never taken digitalis or mercurials.

Examination revealed a middle-aged woman who appeared tired, apathetic, and cerebrated slowly. Fundusoscopic examination revealed marked spasm of the arterioles but no exudate or hemorrhage. The heart was not enlarged. The lung fields were negative to auscultation. The liver was not enlarged. Neurologic examination was negative. Her blood pressure was 280/140.

The electrocardiogram strongly suggested myocardial disease but was interpreted as compatible with hypertension. Urinalysis showed 2 plus albumen, negative for sugar,

specific gravity of 1.011 and many hyaline casts. Phenolsulfonephthalein test was 33 per cent in 1 hour. Non-protein nitrogen was 30 mg. per cent. The nembutal test caused a drop in blood pressure from 245/140 to 200/114. The intravenous etamon chloride test produced a drop in blood pressure from 220/150 to 150/100. The intravenous pyelogram was normal. Roentgenogram of the chest showed no cardiac enlargement. On Nov. 15, 1951, a right frontal craniotomy was performed at Mercy Hospital and the hypophyseal stalk divided without difficulty. The exposure was good and the optic nerve did not have to be retracted. The stalk was divided as close to the diaphragm of the sella as possible, using special scissors. Postoperatively the patient got along well. There was no increased thirst or polyuria. The blood pressure fell progressively and at the end of the first postoperative week the blood pressure was 170/110 and did not go above this level during her hospital stay. She remained apathetic and continued to complain of tiredness. Her blood pressure remained down but 8 months after operation she began to show signs of dependent edema and was put on digitalis. She developed renal failure, became clinically worse and developed generalized edema although her blood pressure was 162/114. She died from uremic poisoning 13 months after operation (fig. 2).

Case 3 V. W. This 33 year old Negro woman complained of severe pain in the left eye and left forehead for 2 years. She had experienced mild shortness of breath for 6 months.

General physical and neurologic examinations were negative except for moderate spasm of the retinal arterioles and blood pressure of 260/180. The electrocardiogram showed left ventricular hypertrophy. Roentgenogram of the chest showed slight enlargement of the heart. Roentgenograms of the skull were normal. The intravenous pyelogram was normal except for a double pelvis on the right. The nonprotein nitrogen was 31 mg. per cent. Urinalysis was negative except for a trace of albumin. Phenolsulfonephthalein test was 40 per cent in 1 hour. Blood Kahn was negative. Neither the sodium amytal test nor the intravenous etamon chloride test produced any significant fall in blood pressure. Tests for phaeo-

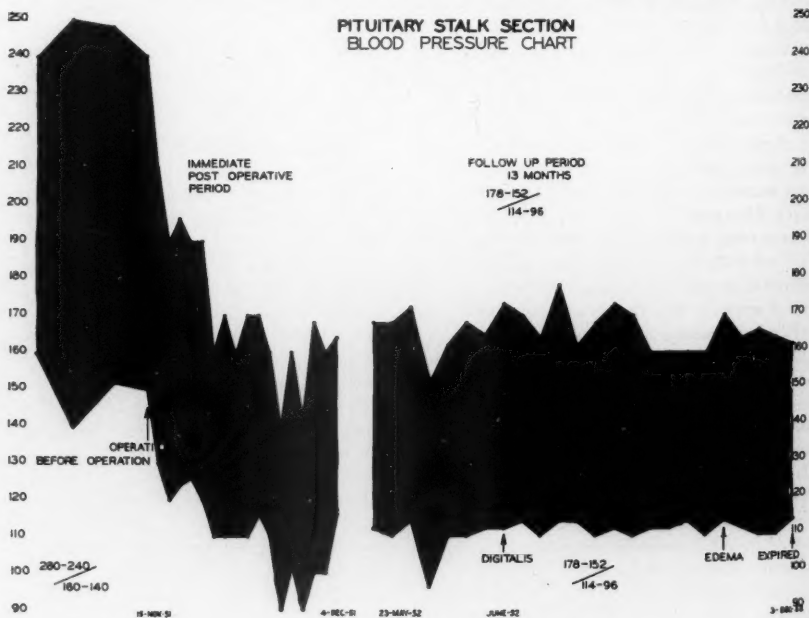


FIG. 2

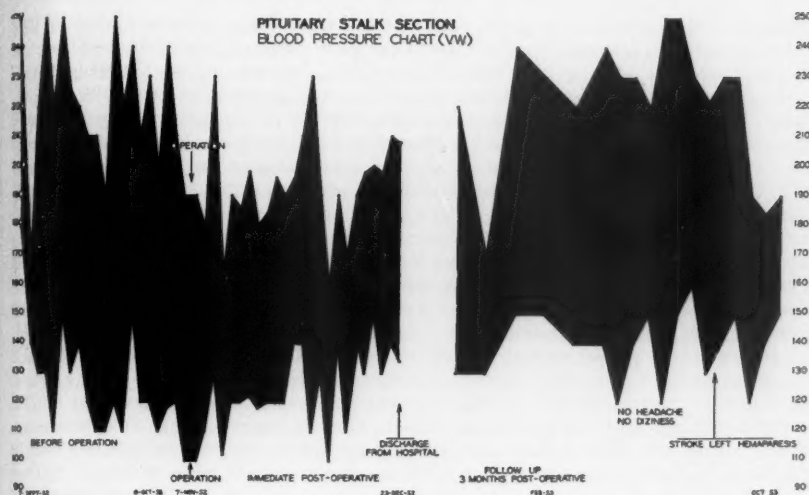


FIG. 3

chromocytoma were negative. The patient was given large doses of both apresoline and hexamethonium until toxic symptoms appeared without lowering of the blood pressure.

On Nov. 7, 1952, a right frontal craniotomy was performed at the Dade County Hospital and the hypophyseal stalk exposed and divided without difficulty. The postoperative course was uneventful but there was no significant change in blood pressure from the preoperative level. There was no abnormal thirst or polyuria. The pain in the left eye and forehead completely disappeared and she felt fine, but her blood pressure remained in the vicinity of 240/140. Postoperative she had no menstrual periods while preoperative her menstrual periods were regular (fig. 3).

Eight months postoperative she had a stroke producing weakness in the right arm and leg with dysphasia which gradually cleared. During this hospitalization her blood pressure was somewhat lower than formerly but following discharge, returned to its former high level. This patient was followed for 1 year, at that time she moved out of Miami area and I have been unable to locate her.

Case 4 H. S. This 44 year old Negro woman was first admitted to Jackson Memorial Hospital in July 1951 for a hemorrhoidectomy and at that time found to be hypertensive; blood pressure 168/130. Approximately 1½ years later she was readmitted because of severe recurrent headaches and convulsive seizures. The attacks began with her inability to speak; she would then black out, jerk all over and was frequently incontinent. Her headaches had become so severe that she was unable to work and they were completely incapacitating to her. Her blood pressure was 170/110. Skull roentgenograms showed hyperostosis frontalis interna. She had slight ankle edema and severe spasm of the retinal arterioles but otherwise her physical examination was essentially normal. Spinal fluid studies were normal. Electroencephalogram was interpreted as normal. Carotid arteriograms and pneumoencephalogram was done and showed no abnormality. Nonprotein nitrogen was 33 mg. per cent. Urine showed a trace of albumin; she concentrated to 1.018. One evening, while in the hospital, her headache was so severe that she attempted to jump out a second story window. She was discharged on Apresoline, to be followed in the medical clinic.

Approximately 6 months later she was readmitted in mild cardiac failure. She was having dyspnea on exertion, palpitation of the heart and ankle edema. Her heart was moderately enlarged; blood pressure 180/140. She continued to complain of severe headache.

Intramuscular hexamethonium produced a significant lowering of the blood pressure, but she was unable to tolerate this medication because of dizziness, visual disturbance and epigastric distress. She was discharged on Apresoline, low salt diet, and Phenobarbital. Her blood pressure remained high and she continued to complain of excruciating headaches. Inasmuch as she had not responded satisfactorily to hypotensive drugs and was desperate because of the severity of her headaches it was recommended that she undergo division of the pituitary stalks. Her blood pressure at that time was 184-170 systolic and 130-140 diastolic. Intravenous etamon chloride test produced no fall in blood pressure and the benzodioxan test was negative. A right frontal craniotomy was done on Aug. 3, 1953 and the pituitary stalk sectioned just above the diaphragm of the sella. For several days postoperative the blood pressure was very low and it had to be maintained in the normal range by the use of levophed. Some of the levophed infiltrated into the right leg and produced a huge slough and for 48 hours postoperative she had almost a complete renal shutdown. A week after the operation she was doing well and her blood pressure was 150/90. At the end of the second week it was 120/80. Her hospitalization was prolonged by the slough on the inside of her right leg which had to be debrided and subsequently skin grafted. On discharge, approximately 2 months after the operation, her blood pressure was 120/70. Immediately, postoperative and several months after discharge, she had moderate polydipsia and polyuria which was controlled by the use of pitressin. She has been followed in the Medical Clinic for the past 2½ years. Her blood pressure has remained relatively normal—130/95 average. She has had no convulsive seizures and she now has no diabetes insipidus. Her headaches have been markedly improved although she continues to complain of some headache. She has mild optic atrophy on the right. She has had no disturbance of her menstrual periods, and no evidence of cardiac failure (fig. 4).

Case 5 J. B. This 47 year old Negro man came to the clinic at Jackson Memorial Hospital in 1950 with the history of known hypertension for 10 years, recurrent convulsive seizures for several years and cardiovascular arrest 1 year previous with a residual left

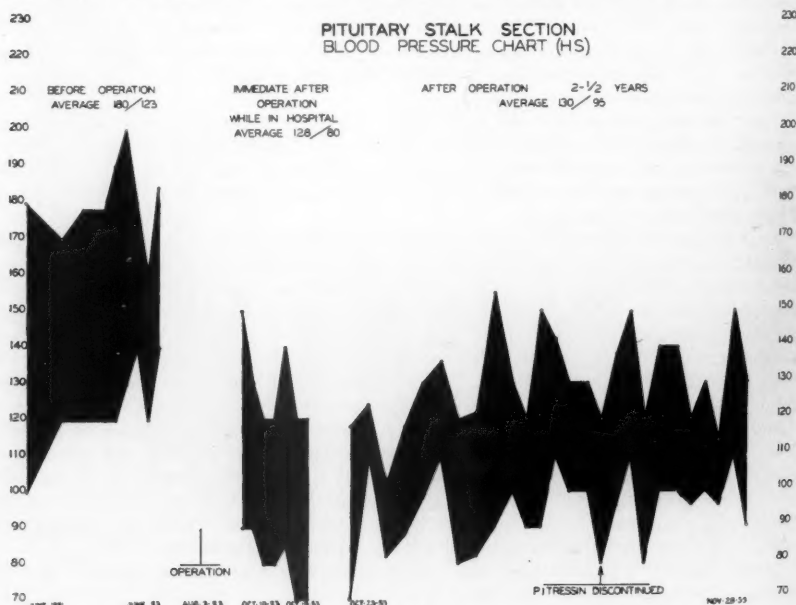


FIG. 4



hemiparesis. At that time his blood pressure was 210/120. He was followed in the clinic during 1952, placed on Apresoline and Rauwolfia without significant lowering of the blood pressure. He was admitted to the hospital in March 1953 because of dizziness and increased weakness in his left side. His blood pressure was 220/160. His regitine test was negative. Phenolsulfonephthalein was 41 per cent. There was no drop in blood pressure following intravenous sodium amytal. He was treated with vasodilators, anticoagulants and apresoline. He was discharged to the clinic but got along poorly and was readmitted to the hospital a month later with blood pressure 200-230 systolic and 140-170 diastolic. He was again discharged on apresoline. In July 1953 he was admitted to the hospital because of focal convulsions in the left arm and leg of 2 days duration. At that time his blood pressure was 280/140. Lumbar puncture revealed normal pressure, protein 23 mg. per cent, cells 0 and Kahn negative. He was placed on Dilantin, the seizures were controlled, and he was discharged to the Medical Clinic.

Two months later he was readmitted again with focal seizures in the left arm and leg. His blood pressure ranged 180-220 systolic and 110-180 diastolic. Spinal fluid studies were again normal. Right carotid arteriogram and a pneumoencephalogram showed no abnormality. Intravenous pyelogram was normal. Intravenous etamon chloride produced no significant fall in blood pressure. The nonprotein nitrogen was 35 mg. per cent and phenolsulfonephthalein 46 per cent. It was thought that this patient had severe hypertensive cardiovascular disease and hypertensive encephalopathy which had not responded satisfactorily to hypotensive drugs and division of the pituitary stalk was recommended. This procedure was performed on the eleventh of December, 1953 through a right frontal craniotomy. Preoperative blood pressure was 200/140. The postoperative course was smooth. There was no polyuria or polydipsia. The blood pressure gradually fell during the next 2 weeks to 130/90 but there continued to be fluctuations in pressure (fig. 5).

This patient has been followed for 2 years and his average pressure has been 158/110 as

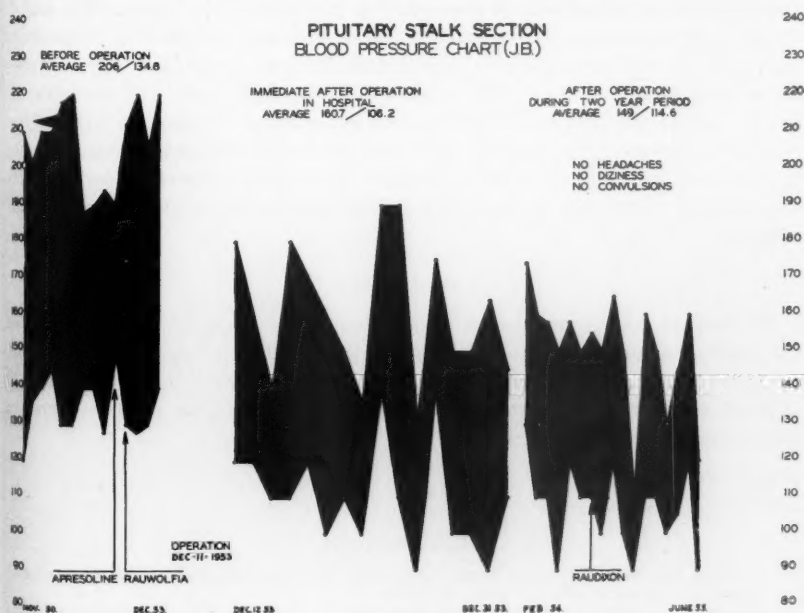


FIG. 5

	Follow Up	Average Preoperative	Average Postoperative	Postoperative	
				Systolic drop	Diastolic drop
L. F.	5½ yrs.	201/120.6	152.3/93.9	48.7	26.7
J. H.	13 mos.	244/150	165.5/111	78.5	39
V. W.	1 yr.	220/125.9	197.5/136	22.5	0
H. S.	2½ yrs.	180/123	129/87.5	51	35.5
J. B.	2 yrs.	206/134	158/110	48	24

FIG. 6. Blood pressure change after pituitary stalk section

compared with his average preoperative pressure of 206/134, a reduction of the systolic 48 mm. and diastolic 24 mm. of Hg. He has had no headaches. His dizziness has disappeared and he has had no more seizures.

Four of these patients have shown a significant lowering of blood pressure (fig. 6).

#### SUMMARY

One has shown no significant change but was completely relieved of her headaches. One patient with secondary hypertension due to renal disease showed marked lowering of her blood pressure but a slowly progressive downhill course to die in renal failure without elevation of the blood pressure. This suggests that the neurohypophysis is involved in the mechanism that produces renal hypertension and tends to confirm the work of Sattler and Ingram<sup>10</sup> in dogs. Two patients showed disturbance of gonadotropic hormone—1 by amenorrhea and 1 by mild gynecomastia. Temporary diabetes insipidus occurred in 1 patient. Two patients with hypertensive encephalopathy with convulsive seizures preoperatively have had no further seizures. Two patients who had evidence of cardiac failure preoperatively have had no evidence of it postoperatively. One patient has severe optic atrophy and 1 has mild optic atrophy. Those patients who showed the best fall in blood pressure after operation were those patients who showed a lowering of the blood pressure after etamon chloride or sodium amytal.

#### CONCLUSION

No definite conclusion can be drawn from these meager observations—yet the results suggest that section of the pituitary stalk in a hypertensive patient (1) will produce significant lowering of the blood pressure in most patients, (2) will not produce permanent diabetes insipidus and (3) may produce signs of gonadotropic hormonal deficiency.

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## VOLVULUS OF CECUM

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Volvulus of the cecum and the ascending colon is an axial rotation of the proximal portion of the right colon due to a developmental lack of fixation of the cecum to the posterior abdominal wall. It is a rare cause of bowel obstruction. Early recognition allows early treatment with a much improved prognosis.

Volvulus of the right colon accounts for less than 4 per cent of all causes of bowel obstruction.<sup>33</sup> It is less common than volvulus of the sigmoid colon, which occurs 2-3 times more frequently than volvulus of the cecum.<sup>3</sup> There seems to be no age preference for the occurrence of volvulus of the cecum, as it has been found in the newborn and is about evenly distributed throughout all of the decades of life. To the present time, about 500 cases of volvulus of the cecum have been reported in the literature, but this collection has been accumulated from many different sources. At the Mayo Clinic 7 cases were reported occurring during a period of 31 years (1915-1946).<sup>7</sup>

The fundamental defect that allows torsion of the right colon to occur, is a failure of the right mesocolon to become obliterated during fetal development. During embryologic development the cecum migrates by rotation from a left sided position to the right side of the abdominal cavity, and then descends from a subhepatic position to the right lower quadrant. The right mesocolon then becomes obliterated and the right colon becomes adherent to the posterior abdominal wall. Failure of this posterior fixation allows a mobile cecum, and such a mobile cecum may become twisted. Since this failure of fixation may be associated with anomalous failure of rotation or hyper-rotation, the cecum which may become obstructed by volvulus is often found in a location distant from its usual right lower quadrant position.

The exciting cause for volvulus of the cecum is not understood. It is seen with apparent increased frequency in pregnancy, before and after delivery,<sup>19, 28, 29</sup> and in the postoperative abdomen.<sup>8, 17</sup> In other cases it has been associated with purging, enemas, constipation, and strenuous or unusual physical activity. In several of the reported cases, acute inflammatory disease of the appendix or pelvic organs was found and this was believed to be a contributory factor. The fact that 11 per cent of the population have cecal mesocolons sufficiently long to allow volvulus,<sup>33</sup> and yet the occurrence of cecal volvulus is of such rare occurrence would indicate that some unusual event or combination of events must operate to produce volvulus.

The symptomatology is that of partial or complete large bowel obstruction. There is usually a sudden onset of severe abdominal colicky pain, most often in the lower abdomen, but it may occur in any region of the abdomen. The pain

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usually persists at its site of origin. Nausea and vomiting occur in over half of the patients soon after the onset of the pain. Physical examination reveals abdominal distention of varying degree and often the distended cecum is palpable or percussed as a large tympanic mass. It should be remembered that the distended cecum will occupy a position other than the right lower quadrant in over half of these patients. When it occurs in the left upper quadrant it is often confused with a dilated stomach. The degree of intestinal obstruction is variable and in some patients flatus and feces may be passed after the onset of the pain, and persist until the colon distal to the site of obstruction is emptied of its contents.

This condition is of special radiologic interest because it can usually be diagnosed specifically from the plain film of the abdomen, and if necessary, be positively confirmed by barium enema examination. The supine and erect films of the abdomen will show a small segment of large bowel markedly distended with gas and with a fluid level in the distended segment in the upright film. The distended segment of bowel, is easily recognized as large bowel because the degree of distention is so great it is beyond the limits of distensibility for small bowel, usually measuring more than 15 cm. in diameter. This distended segment may have some shallow haustral indentions along its borders, further helping to establish its identity as large bowel, although one cannot depend on the demonstration of haustral markings because the distention may be severe enough to obliterate all haustral markings of the distended segment. The dilated mobile cecal segment may be found in any part of the abdomen, and is sometimes confused with a dilated stomach on initial inspection of the radiographs. On closer inspection, the stomach bubble can usually be identified as a separate shadow in its usual location, and if there is still any question, the stomach can be identified with certainty by ingesting a spoonful of barium mixture or the passage of a tube into the stomach.

The absence of any distention in the remainder of the colon localizes the distended segment to the most proximal part of the colon since in bowel obstruction the distention occurs proximal to the site of the obstruction. The colon distal to the site of obstruction may contain gas, especially if the obstruction is not complete, but it will not be distended beyond the normal limits for colon. The small bowel often shows some degree of ileus, but even with severe distention of the small bowel, the diameter of the small bowel will be less than a third of the diameter of the distended cecum.

The above findings would establish a radiographic diagnosis of obstruction of the ascending colon, and if the dilated cecum is found far from its usual location in the right lower quadrant the likelihood of volvulus is increased almost to the exclusion of any other cause for the obstruction. However, if the dilated cecum is found in the right lower quadrant, then the plain films would establish the presence of ascending colon obstruction but would not definitely differentiate the various causes of such an obstruction, including stenosing of the lumen of the ascending colon due to neoplasm, infection, or extrinsic pressure. Positive confirmatory preoperative diagnosis may be readily made by barium enema examination. The barium enema study would indicate the site of obstruction and if

volvulus were the cause, the pathognomonic twisted cone of barium at the site of the obstruction would indicate the etiology of the obstruction.

The operative treatment presents no unusual problem for the surgeon. The volvulus is reduced by untwisting, sometimes requiring decompression of the cecum before the untwisting can be effected. There has been general agreement that wherever the dilated cecum shows signs of questionable viability it should be resected, as only resection gives assurance against recurrence. When there is no question of impaired circulation in the reduced segment there is no general agreement as to what should be done. In most cases reported in the literature there is usually some attempt made to fix the cecum to the lateral abdominal wall, or by fixing it by severing the lateral peritoneal wall of the mesentery of the cecum and placing it over the cecum and suturing the free border to the medial aspect of the mesentery. Such attempts at fixation have not been universally rewarded with prevention of recurrence, and this has led some to advocate resection of the mobile cecum whenever the condition of the patient permits resection.<sup>22</sup> Mortality from this condition has been well over 50 per cent in cases reported prior to the modern day surgical management. In a recent series of 14 cases of volvulus of the cecum in which all of the patients were treated surgically since 1945, Figiel reported only 2 deaths in this group.<sup>10</sup>

Following are 2 illustrative cases of this condition seen at the Jackson Memorial Hospital:

Case 1. This 70 year old, white woman was admitted to the hospital on Nov. 17, 1951, because of severe right lower quadrant pain of 24 hours duration. The pain remained localized to the right lower quadrant and the patient passed no gas or feces since the onset of the pain. She took an enema at home, but obtained no relief of the pain. She vomited one time. Examination of the abdomen showed a "grapefruit" sized mass in the lower right abdomen extending across the midline. The mass was described as "cystic" in consistency, slightly tender to palpation, and very tympanitic on percussion. The initial impression was "possible ovarian cyst with intestinal obstruction." A plain film of the abdomen showed the dilated cecum. A barium enema showed obstruction of the colon in the midascending colon and the proximal end of the barium column showed the typical twisted cone of volvulus. A right paramedian incision was made and the dilated cecum was found in the right lower quadrant extending across the midline. The cecum had rotated 360° axially in a clockwise direction and had a very long mesentery. The bowel appeared viable and was untwisted after incising an adhesion band extending from the omentum to the right lateral abdominal wall. After detorsion, the cecum deflated. The abdomen was closed with no attempt at fixation of the cecum to the abdominal wall. The patient recovered uneventfully and was discharged on the ninth postoperative day. She has been seen periodically in the Outpatient Clinic till the present time (January 1957), because of senile osteoporosis of the skeleton with multiple compression fractures of the spine. There has been no recurrence of the volvulus during this 5 year period of observation.

Case 2. This 52 year old, white woman was admitted to the hospital on Aug. 7, 1955, with a chief complaint of "belly cramps." For the previous 3 weeks she had had intermittent cramps which had become much more severe the past 3 days, and she had had severe obstipation the past 3 days. She had no nausea or vomiting. Examination of the abdomen showed moderate distention, hyperactive bowel sounds, and no mass was palpated or percussed. The initial impression was large bowel obstruction due to malignancy. Roentgenologic examination of the abdomen showed a massively dilated cecum with moderate distention of the small bowel. A barium enema was performed which confirmed the diagnosis of vol-





FIG. 1a

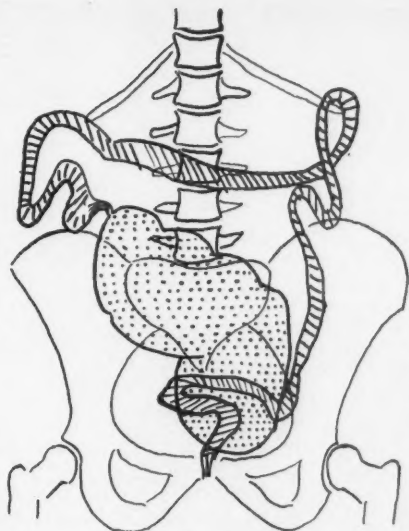


FIG. 1b

FIG. 1. Case 1. (a) Plain film of the abdomen made on admission showing large dilated cecum occupying a midline position in lower abdomen. A few loops of dilated ileum are seen below the cecal shadow and gas is seen in the stomach. The colon is relatively devoid of gas or feces other than the cecum. (b) Line drawing of the appearance of the barium enema film, illustrating the diagnostic criteria clearly. (1) Huge, dilated cecum. (2) Misplaced cecum. (3) Twisted cone of obstruction of the midascending colon.



FIG. 2a

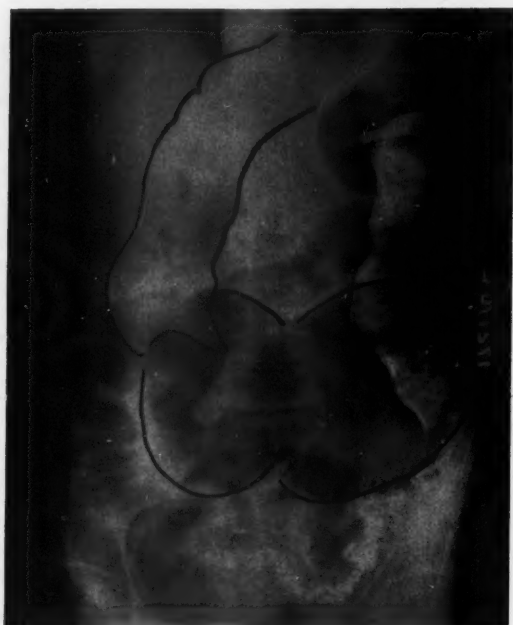


FIG. 2b

FIG. 2. Case 2. (a) Plain film showing dilated cecum to left of midline. (b) Barium enema examination showing characteristic midcolon obstruction with twisted cone of volvulus (retouched).

volvulus of the cecum. Six hours after admission the patient was operated upon through a transverse right upper quadrant incision. The dilated cecum was found in the left upper quadrant and the incision was extended to the left of the midline. The volvulus included the distal 10 cm. of the terminal ileum and the torsion of the cecum occurred about an adhesion extending from an old right lower quadrant incision (appendectomy 1936) to the tip of the cecum. Both the twisted cecum and terminal ileum were gangrenous. Resection of the right colon and terminal 15 cm. of the ileum was carried out with end to end anastomosis of the distal ileum to the transverse colon. The patient recovered and was discharged on the fourteenth postoperative day.

## SUMMARY

Volvulus of the cecum is a rare cause of bowel obstruction but is an urgent problem requiring early surgical treatment. The plain radiograph of the abdomen allows a correct diagnosis in most cases and the barium enema gives confirmatory evidence in every case. Two cases of volvulus of the cecum are reported.

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## THE MANAGEMENT OF PENETRATING WOUNDS OF THE INFERIOR VENA CAVA

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Survival after missile injury of the inferior vena cava is apparently rare. The first case report appeared in 1917,<sup>7</sup> and in 1945 Kidd<sup>5</sup> was able to find only 4 such cases with recovery, in the literature, including a shell fragment injury of his own. Since 1945, three additional successfully treated missile lacerations of the inferior vena cava have appeared in case reports, the injury having been caused by a bullet in 2 instances<sup>1, 3</sup> and by a shell fragment in the third.<sup>4</sup> In addition, there have been 7 patients surviving stab wounds or blunt trauma lacerations of the inferior vena cava.<sup>2, 5, 6</sup> Treatment in these cases of caval injury consisted either of suture of the rent in the vessel, ligation, or application of clamps directly on the cava (with subsequent removal several days later). With a single exception,<sup>3</sup> the sites of injury were below the entrance of the renal veins. In no instance was there evidence of subsequent caval thrombosis, or dislodgement of emboli to the lung.

During a recent 5 month period at Jackson Memorial Hospital, three gunshot wounds of the inferior vena cava have been encountered and repaired successfully. In each patient there was severe concomitant visceral injury. In one patient the contiguous aorta was also ruptured by the bullet and repaired. In another patient the inferior caval laceration was above the renal veins, the second such case with survival of which we have knowledge.

From our experience and from the collective experience of previous workers, certain principles have evolved concerning the management of this potentially exsanguinating type of wound. The objective of this report is to enumerate these principles.

Case 1. This intoxicated 27 year old previously healthy Negro man was admitted to the emergency room at noon on Sept. 8, 1956. He had been shot at close range with a .22 caliber pistol a few minutes before arrival. He was in obvious shock, with a feeble rapid pulse. A cutdown was immediately placed in the leg and plasma started. After nearly 1000 ml. of plasma had been given and 500 ml. of blood started, his blood pressure was 90/60 and his pulse 120 per minute. Gastric aspiration yielded bright red blood and food. Feces in the rectum was nonbloody. Urinalysis was normal. Hemoglobin was 13.6 gms and hematocrit 47.

The patient had a wound of entry midway between the umbilicus and the xiphoid, just to the left of the midline. The bullet could be felt in the subcutaneous tissue of the right costovertebral triangle, approximately 1 inch below the twelfth rib. There was evidence of peritoneal irritation. No bowel sounds were present.

He was taken directly from the emergency room to the operating room where additional resuscitative measures were carried out on the operating table. By 1:45 p.m., 1000 ml. of plasma and 1000 ml. of blood had been given. His blood pressure was 114/80 with a pulse of

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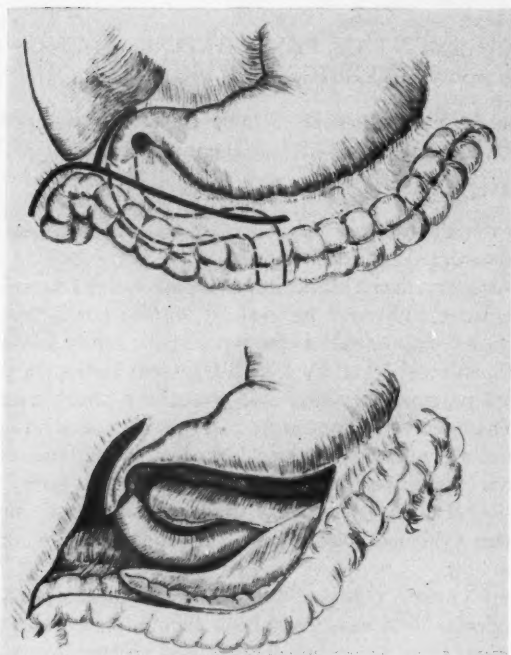


FIG. 1. (After Russell Drake). Peritoneal incisions (upper) and reflections (lower) for exploration of the inferior vena cava, above the level of the renal veins. The location of the bullet tract in Case 1 is indicated by a solid circle.

84. He was anesthetized with cyclopropane and exploration was carried out through a midline incision, from the xiphoid to the umbilicus. On entering the abdominal cavity, a large quantity of blood and bile-stained free fluid welled up into the wound. A perforating wound of the first part of the duodenum was immediately identified (see figure 1). This was on the inner aspect of the second portion of the duodenum and passed through the head of the pancreas. The pancreas was elevated by a large hematoma which had dissected laterally into the retroperitoneal space above the right kidney. There was no active intraperitoneal bleeding.

Because it was feared that laceration of the portal vein or inferior vena cava had occurred, it was elected to perform retroperitoneal exploration before doing any more intraperitoneal manipulation. The midline incision was extended along the right side of the xiphoid process superiorly and below the umbilicus inferiorly. The hepatic flexure of the colon was mobilized inferiorly, and the pyloric aspect of the gastrocolic ligament divided. The superior leaf of the transverse mesocolon was divided and the mesocolon swept inferiorly. Finally, the right lateral peritoneal reflection of the first and second portions of the duodenum was divided as in the Kocher maneuver. This gave wide access to the entire duodenum (fig. 1). Before elevating the duodenum, final preparations were carried out. The cutdown was checked in the leg, as well as an 18 gauge needle in the arm. Curved and straight Potts ductus and bulldog clamps were brought to the operating table. Two thousand ml. of blood were readied for use.

The duodenum was then elevated and the retroperitoneal space quickly entered. At this time a massive hemorrhage occurred with an estimated blood loss of 1000 ml. in a few



seconds. Digital exploration of the inferior vena cava disclosed the presence of a bullet hole which just admitted the full tip of the middle finger. With the finger in place, the hemorrhage ceased and henceforth was not a difficult problem. During the massive bleeding, the blood pressure became unobtainable. With the tamponading finger in place, further operative manipulation was discontinued for 10 minutes while 1500 ml. of blood were given. His blood pressure returned to 120/80 and he remained in good condition for the balance of the procedure.

With the finger in place, the cava was then mobilized and rubber tapes placed proximal and distal to the injury. At the inferior extent of this dissection, the entrance of the renal veins was identified. The wound in the cava was found to be in the right lateral side, with loss of  $\frac{1}{4}$  to  $\frac{1}{3}$  of the vessel substance. The rent was closed with continuous no. 00000 arterial silk. When tested, the site of repair had a constriction of approximately 40 per cent of the diameter.

Next, the first portion of the duodenum was mobilized from the head of the pancreas. Anterior and posterior perforations were identified and closed with two layers of interrupted silk. A choledochostomy was then performed, and it was found by probing that one of the sutures in the anterior duodenal closure had obstructed the common duct. The offending suture was removed and, after demonstrating a patent common duct, a short-arm T tube was left in place. Four Penrose drains were brought through stab wounds; 2 from Morrison's pouch and 2 from the head of the pancreas. During the entire preoperative and operative period, the patient received 4000 ml. of blood and 1000 ml. of plasma.

Convalescence was remarkably benign. The drains erupted large quantities of bile-stained fluid for the first few days but this had ceased at the end of a week and the drains were all removed. He had an ileus for 5 days which was treated by gastric suction. Serum amylase levels were elevated (highest 327 units) for the first week but then declined to normal values (less than 200 units in our laboratory). The wound healed cleanly and all sutures were removed on the seventh day. A T tube cholangiogram on the tenth postoperative day was normal. He was discharged on the seventeenth postoperative day with the T tube in place and clamped off. At no time was there evidence of venous stasis in the lower extremities.

The patient was followed in the outpatient clinic. Five weeks, after another normal cholangiogram, the T tube was removed. He did not return to the clinic and was last seen in the emergency room on Oct. 27, 1956 with multiple lacerations of the head, arms and face, presumably incurred in a knife fight.

Case 2. This 38 year old white man was brought in to the emergency room at 4:27 p.m. on Oct. 19, 1956 a few minutes after having been shot in the abdomen with a .32 caliber pistol. His blood pressure was 50/20 and his pulse was 130. Immediately, a cutdown was placed in each leg and pressure transfusion started with plasma. He was taken at once to the operating room and further resuscitative measures carried out on the operating table.

The patient was intoxicated. There was a wound of entry at the midpoint between the xiphoid and umbilicus, just to the right of the midline. In the left flank was an area of ecchymosis just above the ileum, which was thought to be near the bullet. He had peritonitis.

By 5 p.m., after 1500 ml. of plasma and 100-200 ml. of blood, the blood pressure was 140/80. He was anesthetized with cyclopropane and explored through a long midline incision from the xiphoid nearly to the pubis. On entering the peritoneal cavity, approximately 500 ml. of free blood was removed. A large retroperitoneal hematoma was immediately noted near the midline, below the transverse mesocolon centered midway between the renal arteries and bifurcation and extending both laterally and into the mesentery of the small bowel. It was feared that an aortic or inferior vena caval injury had occurred, despite the fact that serious bleeding had ceased. Two thousand ml. of blood were brought into the operating room and vascular clamps prepared. The entire small bowel was eviscerated to the right. The left lateral leaf of the small bowel mesentery was incised widely at its base. At this point acute fresh bleeding occurred, but this was easily controlled with stick sponge pressure on the widely exposed cava. It was found that the bullet had passed between the

aorta and vena cava. There was a 5 mm. tear in the left side of the vena cava. In addition, there was an injury at the right side of the contiguous aorta with a greatly thinned out bulging acute aneurysm. The 1 cm. acute aortic aneurysm was watched with considerable fascination for the next few minutes, while several surgeons were asked in to view the operative findings. While this was being done, the aorta ruptured with a sudden loss of approximately 500 ml. of blood. The hemorrhage was immediately controlled with finger and stick sponge pressure, and the aortic tear was repaired with 4 or 5 interrupted no. 0000 arterial silk sutures. The laceration of the inferior cava was repaired with a similar technic.

Further examination of the abdomen revealed through-and-through bullet wounds of the stomach and third portion of the duodenum. The 4 perforations were closed with 2 layers of no. 0000 silk. A Penrose drain was led from the retroperitoneal space on the left from near the inferior pole of the kidney out through a stab wound. During the entire preoperative and operative period, the patient received 1500 ml. of plasma and 2500 ml. of blood.

Both cutdowns were removed immediately after surgery. Convalescence was uncomplicated. He was never febrile. An ileus responded to gastric suction by the third postoperative day. Streptomycin and penicillin were discontinued on the fifth postoperative day and he was discharged on the sixth postoperative day. The wound healed per primum and retention sutures were removed in the clinic on the fifteenth postoperative day. He was last seen on Jan. 2, 1957. There has been no evidence of venous stasis in the legs.

Case 3. This 25 year old intoxicated Puerto Rican was brought to the emergency room at 3 p.m. on Jan. 4, 1957 a short time after having been shot twice with a .357 magnum police pistol. He did not appear to be critically injured. His blood pressure was 110/80 and pulse 86. On examination he was found to have 2 wounds of entry. There was a penetrating wound of the right shoulder (which subsequently was shown to be a trivial injury). In addition, there was a bullet wound of the right flank posteriorly. Roentgenograms of the abdomen demonstrated a bullet in the left upper quadrant posteriorly. He had the physical findings of peritonitis with absent bowel sounds. There was no blood in the urine and gastric aspiration did not yield blood. Hemoglobin was 16.1 grams.

Five hundred ml. of plasma were started and he was admitted to the ward. There, evidence of peritonitis became more florid, with intense abdominal pain. He was taken to the operating room at 5:45 p.m. and explored through a midline incision from the xiphoid to 2 inches below the umbilicus. On entering the abdomen, there was less than 200 ml. of free blood present. Bleeding had ceased. Almost immediately, the bullet was encountered in the greater omentum. The transverse colon was next elevated superiorly and a retroperitoneal hematoma noted behind the third portion of the duodenum just proximal to the ligament of Treitz. The peritoneum was incised transversely over the hematoma, the third portion of the duodenum elevated, and a through-and-through duodenal perforation demonstrated.

Until this moment the hematoma had not been manipulated. An exploring finger was then placed into the hematoma and an attempt made to follow the bullet tract. When the finger was withdrawn, it was followed by a massive hemorrhage. The finger was immediately replaced with control of the bleeding.

An incision was then made in the peritoneum lateral to the right colon and the entire right colon swept medially. Good exposure of the cava was obtained and it was possible to apply a curved Potts ductus clamp to the proximal cava, but in doing so one of the lumbar veins was torn from the side of the parent vessel creating another small linear caval tear. A tape was passed around the right iliac vein and a straight Potts ductus clamp applied to the left iliac vein. Despite these maneuvers, finger pressure was still necessary at the site of the bullet injury due to the efflux of blood through the intervening lumbar and middle sacral veins.

The caval injuries were assessed at this time and were found to be about 2 inches above the bifurcation. There were lacerations on both the anterior and posterior surfaces of the vessel, each about 1.5 cm. long, indicating a through-and-through bullet injury. In addition there was a 1 cm. laceration superior to this where the lumbar vein had been torn off. These

were repaired with continuous no. 00000 arterial silk. Just as repair of the third laceration was completed, hemorrhage was noted in the pelvis. Investigation showed that the Potts clamp on the left iliac vein had cut through the vessel wall, creating a 4 mm. transverse laceration. This was sutured with no. 00000 arterial silk.

The two previously demonstrated perforations of the third part of the duodenum were then closed with 2 layers of no. 0000 silk. Further examination disclosed a through-and-through perforation of the proximal jejunum and this was closed in a similar manner. Prior to surgery the patient had received 500 ml. of plasma. During the operation he received 4000 ml. of whole blood and 500 ml. of plasma expander.

Postoperatively, the patient had an adynamic ileus. Bowel sounds returned on the fourth postoperative day. On the seventh day, he developed evidence of thrombosis of the left ileo-femoral system, presumably at the site of the Potts clamp injury to the femoral vein. There was no swelling of the right lower extremity at any time. He was treated with anti-coagulants with subsequent disappearance of the signs of thrombosis. He was discharged on the twentieth postoperative day in good condition. He was last seen on 25 March 1957 at which time there was no evidence of venous stasis in either leg.

#### DISCUSSION

In all cases of caval injury reported previously, and in the present series as well, serious hemorrhage had ceased by the time celiotomy was performed and the only evidence of a serious venous injury frequently was a disarmingly small retroperitoneal hematoma. It is quite possible that, with this spontaneous tamponade, no further venous hemorrhage would occur if the retroperitoneal space were not explored. It is, however, not possible for the surgeon to be certain of this. In addition, it is frequently necessary (as in the present series) to carry out such exploration for the detection and management of other retroperitoneal injuries which, if left untreated, would lead to almost certain mortality. Therefore, when the trajectory of a missile projects to or near the great vessels, we believe that a planned program designed to give exposure of the potentially injured vessel should be instituted. There is no need for haste, since recurrence of hemorrhage need not be anticipated until the retroperitoneal dissection is begun. Lighting can be adjusted, necessary vascular instruments obtained, additional assistants summoned, and additional blood crossmatched. During this period of preparation, manipulation of the hematoma should be carefully avoided.

For injuries at or below the level of the transverse mesocolon, the inferior cava can be explored either by evisceration to the right followed by incision in the left leaf of the small bowel mesentery at its base (Case 2, fig. 2) or by evisceration to the left followed by reflection of the right colon to the left (Case 3). The former approach is superior if concomitant aortic injury is suspected, while the latter approach is superior if evidence is present of a right renal injury. Dissections on cadavers have demonstrated that a combination of the above two dissections leads to an extraordinarily broad exposure of both the aorta and the inferior cava. In this maneuver, the entire small bowel, right colon, and related mesenteries are reflected in a cephalad direction.

For injuries above the level of the transverse mesocolon, the approach used in Case 1 (fig. 1) is probably the best, consisting of mobilization of the hepatic flexure, transverse colon and transverse mesocolon inferiorly combined with a Kocher maneuver. By any approach, the dissection can be carried out with lei-

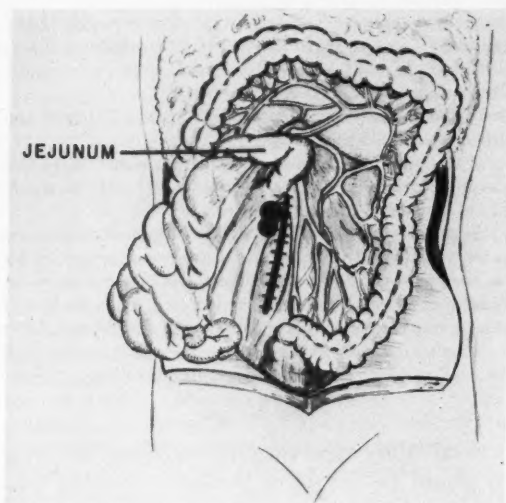


FIG. 2. (After Kay Hyde). Peritoneal incision through the left leaf of the small bowel mesentery, at its base, for exposure of the inferior vena cava below the transverse mesocolon. The upper and lower solid circles indicate the levels of caval injury in Cases 2 and 3 respectively.

sure until the plane of the hematoma is reached, but from this point on the dissection is done rapidly.

After bleeding is controlled by pressure, repair may be possible (Case 2) or proximal and distal isolation of the lacerated vessel may be necessary before suture is feasible. It is our opinion that suture repair is almost always more desirable than caval ligation.

In one of the present patients, it is probable that thrombosis of the iliac vein occurred. This is the only such complication recorded in the small series of caval injuries to date. The patient in question had 4 suture lines; 3 in the cava and 1 in the iliac vein. We believe that anticoagulant therapy should be considered in such a patient with multiple venous injuries.

#### SUMMARY

Three consecutive gunshot wounds of the inferior vena cava successfully treated with suture repair are presented. These represent the eighth, ninth, and tenth cases of missile injury to the inferior cava, with survival, in the literature. Recovery in one patient was complicated with external iliac thrombosis.

One of the patients had an associated aortic laceration, also sutured. All the patients had additional multiple serious visceral injuries.

One of the caval injuries was above the level of the renal veins; the second such case, to our knowledge, in the literature.

In these 3 patients, as well as almost all others in the literature, massive bleeding had ceased by the time of celiotomy. The signal finding was the presence

of a retroperitoneal hematoma. By probing or manipulating the hematoma, the surgeon may precipitate a massive hemorrhage at a time when he is ill-prepared to deal with it.

When such a retroperitoneal hematoma is found in the vicinity of the great vessels, a methodical program for exploring the retroperitoneal space should be instituted before any manipulation is done. This should include procurement of a large quantity of blood, adjustment of lighting, preparation of necessary vascular instruments, and planned wide exposure.

For caval injuries at or below the transverse mesocolon, one may approach the retroperitoneal space by reflection of the small bowel and its mesentery to the right (Case 2, fig. 2) or by reflection of the right side of the colon to the left (Case 3). The ultimate in exposure is gained by a combination of these maneuvers, reflecting the small bowel, right colon and related mesenteries in a cephalad direction. For injuries above the transverse mesocolon, the hepatic and transverse colon as well as the transverse mesocolon are swept inferiorly. The retropancreatic area can then be entered with wide exposure with the Kocher maneuver (Case 1, fig. 1).

It is our opinion that postoperative anticoagulation therapy is not routinely necessary but should be considered in multiple or unusually severe caval injuries.

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## MANAGEMENT OF NONPENETRATING THORACIC INJURIES\*†

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### INTRODUCTION

The vast majority of nonpenetrating chest injuries seen in civilian practice are sustained in automobile accidents. However, an increasing number of these injuries are also due to air travel, use of farm machinery and industrial accidents. These injuries chiefly involve the thoracic cage, underlying lungs and heart. Less frequently the great vessels, esophagus, diaphragm, thoracic duct and tracheobronchial system are involved. The resulting high morbidity and mortality rates are due to derangements of the function of the intrathoracic organs, especially the cardiorespiratory system.

Joint cooperation and consultation between the various specialists is extremely important. The trend over the years has been to admit patients with injuries for fractures on orthopedic services where attention may be focused upon the fractured humerus, femur, or even fingers and toes, to the exclusion of attention to the fractured ribs, cardiac contusion or other important intrathoracic structures, until serious and often irrevocable physiologic derangements have occurred. The same may be true of a simple skull fracture with associated serious thoracic injury. Attention to this aspect of the problem plus awareness of the possible serious consequences of various anatomic and physiologic changes will do much to decrease the unnecessarily high mortality rate from chest injuries. Emergency and definitive management will be presented.

### EMERGENCY MEASURES

Often valuable time is lost in the hospital accident room while roentgenograms are being taken and interpreted, while a private physician is being called, blood is typed and cross matched and other detailed laboratory work is being done. For obvious reasons the accident room care may be the weakest link in the chain of management. Many deaths are due to poor management during early hours after the accident, many of which have been spent in the accident room of the hospital.

As in all other injuries, the initial treatment should be directed toward relief of shock. Shock or impending shock may not necessarily be due to blood loss or to the extent of tissue damage but to hypoxia and hypercapnia secondary to paradoxical breathing, pneumothorax and accumulation of fluid and/or blood in the lungs and tracheobronchial tree. Prompt and adequate control of pain is a real emergency measure and is very important in the prevention of shock and in obtaining the desired cooperation from the patient. While simple preliminary measures are being taken to relieve pain, shock and hypoxia, examination of the

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chest and an upright portable roentgenogram of the thorax should be performed in order to determine the extent of injury. Physical examination of the thorax is not completely reliable and should not take the place of a roentgenogram of the chest. Plasma or plasma expanders should be started. Blood should be typed and made available for transfusion. It is quite important to maintain the normal circulatory blood volume but great caution must be used to prevent sudden overloading of the circulatory system and precipitation of pulmonary edema. Oxygen should be administered. In the severely injured patient with flail chest due to multiple rib fractures, Jensen<sup>8</sup> has described an ingenious method for administering continuous positive pressure oxygen through a tracheostomy. He presents convincing evidence that it prevents paradoxical motion of the chest cage and its serious secondary effects. More recently, Avery and Morch<sup>1</sup> have presented "A New Method of Treatment by Internal Pneumatic Stabilization with Continuous Mechanical Hyperventilation". They have been able to maintain this type treatment for one month with success and without apparent ill effects.

Stabilization of the chest wall to correct the paradoxical chest motion and introduction of an intrapleural catheter to relieve a tension pneumothorax when it is present are absolute necessities in the prevention and treatment of hypoxia and shock. Early establishment and maintenance of an adequate airway is very essential. Unless profound shock is present, the patient's head should be elevated. On rare occasions an emergency thoracotomy will be necessary to institute cardiac resuscitation, control hemorrhage or to repair a fractured bronchus or trachea. On a number of occasions intravenous cortisone F has been used in the early course of treatment and repeated for several days. This has been particularly useful in the asthmatic and emphysematous group.

After initial emergency treatment has been instituted, the necessary physical examination made and roentgenograms evaluated, attention is focused upon the more definitive measures. However, in most cases it will be only a matter of continuation or maintenance of emergency measures already instituted. Constant meticulous nursing care is of utmost importance from the outset. Frequent visits by the responsible physician are necessary. Shefts<sup>9</sup> reminds us that inadequate response to proper emergency or resuscitative measures should focus our attention on the possibility of intraperitoneal hemorrhage or continued intraperitoneal contamination from rupture of some portion of the intestinal tract.

#### CONTROL OF PAIN

Control of pain is an integral part of the management of chest wall injuries and has much to do with prevention of shock, hypoxia, respiratory acidosis and maintenance of an adequate airway by preventing splinting and permitting a more effective cough. Apprehension and restlessness are due to hypoxia, pain or impending shock. Thus, care should be taken in administering sedation to a patient because of respiratory center depression and interference with the normal cough reflex. Heavy sedation or sedation too frequently administered is capable of doing a great deal of harm to the patient with an injured thorax. The use of morphine, atropine and barbiturates should be avoided.

Frequently an initial intercostal nerve block with procaine is sufficient to control pain. Mild sedation can then keep the patient comfortable so that he can be turned, made to cough, and a more normal physiologic state maintained. Injecting the fracture sites with procaine is a good means of controlling the pain. When there are multiple rib fractures or comminuted fractures of the ribs, injection of 2 or 3 cc. of 1 per cent procaine between the transverse processes of the involved ribs, as suggested by Carr,<sup>3</sup> is a satisfactory way of controlling the pain. The response to intercostal nerve block is usually quite dramatic, in that the patient will promptly expectorate a large quantity of bronchial secretions. When there are extensive bilateral rib fractures or for some other reason it is not feasible to properly position the patient for the nerve blocking procedure, intravenous procaine given very cautiously has been quite effective in the control of pain. Frequent small doses of meperidine and levo-dromoran have proved satisfactory in controlling the pain. Doses of 15 to 25 mg. of meperidine given intravenously has proved of real value. Small doses of chloral hydrate may be used to allay apprehension.

#### RIB AND STERNAL FRACTURES

There are usually extensive rib fractures in the serious chest injury. Many of the other associated injuries or complications are directly or indirectly attributable to the rib fractures. It is thus obvious that early attention should be focused upon the fractured ribs and the resulting deranged physiology. Mobility of the chest wall due to extensive anterior rib fractures, fractures of ribs at more than one location, steering wheel injury or costochondral fractures and especially extensive bilateral anterior or lateral rib fractures, require careful management. Fracture of one or two ribs or even more extensive posterior rib fractures seldom produce real trouble. The latter statement may not be completely true if one is dealing with an elderly individual or one with poor cardiopulmonary reserve.

Rib fractures are not important as such but are of great importance because of the secondary alteration of pulmonary physiology. The paradoxical chest wall or so-called flail chest sinks in upon inspiration and moves out with expiration, the mediastinum shifts, the diaphragm fails to move properly and a portion of the shifted column of air is rebreathed between the two lungs, so-called paradoxical breathing. The intrapleural pressures are altered. Cough is ineffective resulting in accumulation of secretions or other foreign material such as blood, in the tracheobronchial tree. As a result, much of the respiratory effort is wasted and exhaustion results from the increased load and the necessity for the use of all accessory respiratory mechanisms. Thus hypoxia and respiratory acidosis occur. Generally speaking, management of rib fractures is not difficult. The simple injury requires no active treatment although some prefer to strap the chest lightly with adhesive tape. There is strenuous objection to tight strapping or any constricting type bandage such as a vest, an orthopedic belt or any similar appliance. These interfere with pulmonary function, encourage retention of secretions, overlap rib fragments, resulting in more pain and increased chances of laceration of the lung and intercostal vessels. The management of the paradoxical segment

of the thoracic cage consists of immobilization or stabilization. This can be accomplished in any of the following ways: Adhesive tape strapping over a soft pad, soft tissue traction by the method of Hudson, McElvenny and Head,<sup>7</sup> bony traction applied to ribs or sternum and on rare occasions by open reduction and fixation of fragments of ribs or sternum as described by Coleman.<sup>5</sup> Shefts<sup>9</sup> describes a method of immobilization or fixation of the sternum or flail area of chest wall by the use of a wire ladder splint ("Jacob's ladder") in the same manner one stabilizes the sternum after operation for correction of pectus excavatum. This method permits early ambulation.

Whenever necessary, adhesive strapping over a soft pad may be used to correct mobility of fractured ribs or the loose sternal plate. It is permissible to cross the midline anteriorly but the strapping should not encircle or unduly constrict the thorax. In females with large breasts, strapping the breasts into a mobile defect is quite satisfactory. Stabilization of the thoracic cage by strapping makes early ambulation possible. After the strapping is removed in 6 to 10 days the depressed area of the thoracic cage will correct itself rather satisfactorily. It should be remembered that the adhesive strapping may require reapplication or reinforcement frequently to maintain the desired pressure, especially in hot weather.

Occasionally wire or towel clip traction upon the central one or two ribs of the paradoxical chest wall is used for several days. Traction on the soft tissues overlying the flail area is often effective and a great deal easier to accomplish in the obese or very muscular chest wall. On a few occasions, in the presence of a depressed and paradoxical area of chest wall due to fracturing at two levels, open reduction and fixation of fragments with wire sutures has been used.<sup>5</sup> This method has been almost completely abandoned by the author because the other simple methods have usually been effective. It has been used almost entirely in the older, poor reserve group.

Wire or heavy silk sutures can be placed about ribs by making small incisions over the appropriate rib or ribs and by using a large, round suture needle, aneurysm needle or sharp pointed Semb ligature carrier. Quite often there is an underlying pneumothorax which makes the procedure easier and removes the potential danger of puncturing the lung with the instruments used. Avery and associates<sup>1</sup> have devised a new method of mechanical intermittent positive pressure hyperventilation to be used in selected cases of severely crushed chests when external stabilization of the critically injured thoracic cage fails to provide adequate ventilation. The patient is kept apneic and the continuous passive hyperventilation produces slight respiratory alkalosis.

#### ADEQUATE AIRWAY

A free airway is of vital importance in the treatment of thoracic trauma. It is necessary in order to assure adequate oxygenation of the blood and the elimination of carbon dioxide. The simple maneuver of elevating the head rest improves respiratory function and facilitates an effective cough. Stabilization of the chest wall and control of pain do a great deal toward establishing and maintaining an

adequate airway and making it possible to cough effectively and to assure proper air exchange. If hypoxia persists, increased capillary permeability occurs with resulting pulmonary edema. In addition, there is a considerable accumulation of plasma and blood in the traumatized lung. The use of an oropharyngeal airway is of value in facilitating the removal of secretions from the mouth, pharynx and larynx. An endotracheal tube or a catheter placed in the trachea of unconscious patients may increase the ease of removal of tracheobronchial secretions and blood. This is usually not well tolerated for any considerable length of time, particularly when the patient regains consciousness. An hourly turning and coughing routine along with adequate support of the traumatized chest with the hands and stabilization of flail area are important measures. Slow, deep inspiration and rapid forced exhalation will often help dislodge tenacious secretions making the cough more productive. When these measures are not completely effective, transnasal catheter aspiration of the trachea and bronchi is necessary. It is simple but requires the services of a physician at frequent intervals, in many cases. A no. 16 or 18 French size open tip catheter is used. Many times the regular urethral catheter is not long enough and one is fashioned from a Levine tube. The head is deviated to the opposite side of the bronchus to be aspirated. A side vent or Y glass tube insertion into the suction system should be used to make it easier to release suction at frequent intervals. The latter makes it quite simple to connect oxygen when suction is being interrupted. Continuous suction should not be maintained through more than three respiratory excursions. Otherwise, severe hypoxia can result. On a few occasions auricular fibrillation has been seen to ensue. Three to 5 cc. of  $\frac{1}{2}$  strength Alevoire\* instilled through the catheter is an aid in aspiration of thick secretions. The instillation of 1 or 2 cc. of 5 per cent pontocaine has seemed effective in relieving bronchial spasm and increasing the productivity of the cough.

Sometimes this method may fail due to lack of cooperation by patient or because the secretions may be too thick. Bronchoscopy is then indicated to assure complete clearing of the tracheobronchial tree. It may be performed as a bedside procedure. If some type of frequent or prolonged tracheobronchial suction is necessary, a tracheostomy is advisable both from the standpoint of its effectiveness in making it possible to adequately clear the bronchial tree at frequent intervals and also because it is less taxing to the patient. Carter and Giuseffi<sup>4</sup> demonstrated that tracheostomy has other advantages in that dead space is decreased, effective tidal air increased, respiratory resistance decreased and paradoxical motion of the chest wall is decreased. Further, it is an aid in preventing increase of pneumothorax, subcutaneous and mediastinal emphysema thereby facilitating re-expansion and the healing of the badly lacerated surface of the lung. It prevents the building up of high intrapulmonary pressure when the glottis is closed, such as takes place during coughing. However, because of the loss of the cough mechanism, the tracheostomized patient requires diligent observation and frequent endotracheal suctioning.

Aerosol therapy using Alevoire,\* bronchodilators and antibiotics are especially

\* Winthrop-Stearns.

valuable in the patient with increased or retained purulent bronchial secretions. Appropriate oral or parenteral antibiotics are of real value. In some cases with a very irritable tracheobronchial reflex, a few drops of .5 per cent pontocaine instilled into the tracheostomy tube a few minutes prior to aspiration will greatly relieve the amount of discomfort, allay apprehension, encourage patient cooperation and help to conserve the patient's strength.

#### PNEUMOTHORAX

Pneumothorax may be minimal, moderate, or of the tension type, on one or both sides. Extensive bilateral pneumothorax is often fatal unless relieved very promptly. It is obvious that a pneumothorax of any considerable degree alters the respiratory function appreciably. Even minimal or moderate pneumothorax may be very serious in an elderly individual or one with poor respiratory reserve.

The treatment of choice for more than minimal pneumothorax is catheter decompression. It is a simple procedure and consists of placing a no. 24 to 30 French size catheter or rectal tube through a trochar into the intrapleural space through the second or third anterior intercostal space. As a rule the tube leading from the thorax to the water seal should be placed under  $\frac{1}{2}$  to 1 cm. of water to allow the air to escape without building up any positive pressure in the intrapleural space. After a few hours a suction pump which exhausts a large volume of air may be connected to the water seal system. This is of particular value if it is obvious that there is further leakage of air or if the pneumothorax space has not yet been obliterated. A pump which will remove a considerable amount of air is necessary. Otherwise when the patient coughs or in any way increases the intrapulmonary pressure, positive pressure may result in the intrapleural space because the pump is unable to remove the air as rapidly as it escapes into the pleural cavity. If there is more than a minimal leakage of air the low-grade decompression Stedman pump is inadequate.

It is probably unwise for one to treat a pneumothorax of a moderate degree conservatively but if such a course is followed, very careful personal attention is necessary. Several deaths have been observed directly related to such management. Inhalation anesthetics must not be administered until the pneumothorax is relieved, for further escape of air or oxygen may produce a tension pneumothorax during anesthesia and surgery. It is absolutely mandatory that catheter decompression treatment be used in the presence of tension pneumothorax or a bilateral pneumothorax.

Occasionally one encounters a shock-like syndrome resulting from rapid re-expansion of a pneumothorax which has been present for several days or when there is associated bronchial obstruction. This can be prevented by unclamping the decompression catheter for a few seconds at regular intervals, or by placing the tube leading into the pleural space under 16 to 20 cm. of water initially and then gradually decreasing its depth. If dyspnea, pain or shock occurs, the tube may be immediately disconnected to let some air return to the intrapleural space. The above management is then followed for gradual decompression to allow slower expansion of the lung without mediastinal shift. If re-expansion fails to



take place rather promptly and is not due to continued escape of air from the lacerated lung, bronchoscopy should be performed since the failure of re-expansion is occasionally due to bronchial obstruction.

On rare occasions, even with a high rate decompression pump, the pneumothorax cannot be relieved and this usually indicates fracture of a bronchus or the trachea. This demands immediate thoracotomy with repair of the bronchus, if possible. If repair is not possible, resection of the portion of the lung distal to the fractured bronchus must be carried out. Tracheal injuries are even more unusual but must be repaired promptly in order to save the patient. In 1951 the author and associates successfully repaired a severed trachea immediately proximal to its bifurcation.

Until recently, there was great reluctance among physicians to use the catheter decompression treatment of pneumothorax as outlined. It has now been generally accepted by most physicians treating thoracic diseases. The procedure is simple and greatly minimizes morbidity, decreases recovery time and may actually be life saving. It is believed that the lung heals faster, more completely, and bleeding is minimized by expansion of the lung against the chest wall. Respiratory function is improved and the effectiveness of cough is increased by re-expansion. Subcutaneous and mediastinal emphysema are complications, as a rule, of pneumothorax and direct treatment of the pneumothorax is usually all that is necessary for the correction of these two conditions. Rarely has either of them been of such severe degree as to necessitate any treatment directed primarily toward them. They can be recognized by a hoarse nasal-toned voice, mediastinal crackling and by palpating the neck.

#### HEMOTHORAX

This condition is often associated with pneumothorax and it is practically always associated with fairly extensive rib fractures. This is considered to be one of the serious complications of thoracic injuries. It requires rather careful attention for three reasons: 1. It interferes with ventilatory exchange by decreasing lung volume. 2. Blood which is not aspirated usually clots within the thorax making aspiration of it very difficult or impossible, and results in an organizing hemothorax. The resulting fibrothorax is a rather crippling condition necessitating a major operative procedure. 3. Continuing hemorrhage indicates serious vascular injury and surgical intervention is necessary. However, prolonged hemorrhage from peripheral lung injury or from the intercostal or internal mammary vessels is uncommon. Vital signs should be carefully charted. Frequent examinations and roentgenograms of the seriously injured, and prompt treatment of severe or continuing hemorrhage, are of vital importance. Prompt re-expansion of the lung is essential. Blood should be aspirated as often as a few hundred cubic centimeters re-accumulate. The aspirated blood should not be replaced with air.

If hemothorax is associated with pneumothorax, the patient may be positioned to evacuate the blood through the intercostal decompression tube. The tube is then flushed with saline solution to eliminate blood clotting within the tube.



However, the use of a dependently placed tube to remove blood from the intrapleural space has not been reliable in the author's hands because clots often plug the tube. Needle aspiration has been more successful. On a few occasions anticoagulants have been introduced into the hemothorax space through a tube or needle and no complications have resulted. The anticoagulants which have been used are heparin and sodium citrate. If the blood is permitted to remain in the pleural space and clots, fibrinolytic agents may be used 5 to 7 days following the injury and is an effective method of treatment. Occasionally delayed removal of a large volume of blood results in coughing, tightness, dyspnea, pulmonary edema and a shock-like state. Treatment for this complication consists of replacing a portion of the aspirated fluid with air or saline solution.

#### PULMONARY INJURIES

Quite often there is contusion, laceration and hematoma formation. Sometimes trauma to the lung is sufficient to produce considerable accumulation of blood and plasma in the lung parenchyma and the tracheobronchial tree plus a greatly increased volume of mucus on a secondary irritative basis. Rarely a pulmonary vessel, bronchus or trachea may be lacerated or torn either by the force of the injury or by rib fragments. Very rarely torsion of the lung occurs resulting in gangrene due to interference with blood supply to the lung. A case of this is being published elsewhere. It is the first surviving patient with torsion of the lung whose case is to be reported. Quite often trauma to the lung is associated with hemopneumothorax and is usually associated with fracture of one or more ribs.

Rib fragments embedded in the lung occasionally will necessitate open thoracotomy and elevation or removal of the fragments. This has rarely been necessary. Occasionally clotted blood within the bronchial system may require bronchoscopic removal. However, more often the use of Alevaire\* and/or dilute solutions of streptokinase and streptodornase plus endotracheal aspiration will suffice. If major pulmonary vessels, bronchi, or trachea are severely injured, open thoracotomy is indicated but this is a rather infrequent injury or complication. Torsion of the lung demands immediate thoracotomy since the lung will otherwise become gangrenous. Rarely will it be necessary to operate and repair a laceration of the lung. In summary, the traumatized lung itself seldom necessitates primary attention but it is the other associated injuries and complications as previously described which require most of our attention.

#### CARDIAC INJURIES

Carr<sup>3</sup> pointed out that when an automobile is traveling 60 miles an hour and immediate deceleration takes place, the chest is jammed against the steering wheel with the same speed or force that is attained if one falls from a 12 story building. Such an impact drives the sternum against the spine and the heart is caught in the "squeeze" and may become seriously injured.

Contusion, laceration or rupture of a cardiac chamber or coronary artery may

\* Winthrop-Stearns.

produce pericardial tamponade, auricular fibrillation, cardiac decompensation and a shock-like syndrome. On occasion, ventricular fibrillation or cardiac arrest may occur shortly following a severe injury over the precordium. Rarely will resuscitation be possible because seldom is an anesthetist or some other capable person available with the necessary equipment to inflate or oxygenate the lungs while cardiac massage is being instituted. Also, it is probable that a greater number of patients will be lost by cardiac massage under unfavorable conditions than when no attempt is made to resuscitate the heart because, on some occasions, the patient may be in shock or have very feeble heart function without having actual cardiac arrest. Some of these will recover without any surgical intervention, whereas most will be lost if the thorax is opened under unfavorable conditions for apparent cardiac arrest. Contusion of the heart is quite common but other injuries mentioned are, fortunately, uncommon. Of course, rupture of cardiac chambers or laceration of the heart usually necessitate immediate surgical intervention. Cardiac contusion produces changes very similar to a coronary occlusion and should be treated in a similar manner. Coronary occlusion of a temporary or permanent type may result from myocardial hematoma formation or actual traumatic thrombosis. A patient with such injuries should remain in bed for at least 2 weeks. Pericardiocentesis should be performed if there is pericardial effusion.

In order to follow the course of cardiac injuries, frequent roentgenograms, serial electrocardiograms and consultations are required. An initial electrocardiogram is necessary as a means of evaluating any abnormal findings on subsequent tracings. Great effort should be made to avoid producing cardiac neurosis or unusual alarm by too frequent electrocardiograms, examinations, or in any way focusing too much attention upon the heart. The compensation angle is being overplayed.

#### OTHER ASSOCIATED INJURIES OR COMPLICATIONS

*Trauma to the Great Vessels:* Laceration or rupture of a major intrathoracic vascular structure is a rather rare occurrence in nonpenetrating injuries. Occasionally, however, there will be hemorrhage from the vena cava, aorta, pulmonary vessels or one of their tributaries or branching vessels. If this type injury occurs, severe and continuing hemorrhage is the rule and prompt thoracotomy for control of hemorrhage and repair of the vascular structure is indicated.

*Thoracic Duct Injuries:* A lacerated or torn thoracic duct is a rather rare complication of nonpenetrating thoracic injuries. The injury to the duct may occur anywhere along its course from the upper abdomen to its entrance into the subclavian vein at the base of the neck. This may prove to be a mild or serious complication depending upon the extent of the injury and the amount of escaping chyle. If the leakage of chyle is considerable for an appreciable length of time, a state of weakness, malnutrition and marked weight loss result.

Unless it is necessary to perform an open thoracotomy for some other reason, the treatment of choice is repeated aspiration of chyle from the involved pleural space. The vast majority of injuries to the thoracic duct will heal in a period of

5 to 21 days. If there is a large or persisting fistula, resulting in massive chylothorax, it is necessary to ligate the thoracic duct below the point of injury.

*Esophageal Injury:* Perforation or rupture of the esophagus most often follows penetrating wounds of the thorax or instrumentation of the esophagus. However, on rare occasions the esophagus may be ruptured by the impact of a nonpenetrating injury of the chest or by a displaced bone fragment. It is a very serious complication warranting immediate recognition and treatment. It may be overlooked or the condition may be difficult to recognize because of other associated injuries. It should be strongly suspected if there is severe pain upon swallowing and localized subcutaneous emphysema originating about the base of the neck anteriorly. In addition, there may be some tenderness and later redness over the anterior portion of the neck and manipulation of the larynx is quite painful. A rapid rise in temperature, pulse and leucocyte count occurs. If the condition is recognized early and the patient's condition will permit, the esophageal injury should be repaired. If it is not recognized until late, or if the patient's condition will not permit repair of the defect, the comparatively simple procedure of drainage of the involved periesophageal area is performed. Of course, gastric suction, intravenous fluids, and a massive antibiotic routine are indicated. Empyema is a late complication of rupture or perforation of the esophagus and requires open or closed tube drainage.

*Diaphragmatic Injury:* This is one of the uncommon associated injuries or complications of thoracic trauma. A blow on the abdomen or lower thorax may increase the intra-abdominal pressure to the extent of rupture of a leaf of the diaphragm and herniation of the liver and/or other abdominal structures through the diaphragm into the thorax. Symptoms from this may be minimal but as a rule there is considerable interference with cardiorespiratory function and to a lesser extent function of the herniated organs. This complication occurs most often on the left side because of the protection of the liver on the right. The condition is usually not difficult to recognize if suspected. The diaphragm or what is interpreted as the diaphragm appears at a much higher level than normal and careful examination of the roentgenogram may reveal herniated intestinal loops in the thorax. Fluoroscopy may be of considerable value in its recognition. On rare occasions the diaphragm may be traumatized so that it does not function normally and may be markedly elevated without actual rupture. This has been observed on several occasions and with return of normal function in a few days. On one occasion the author has seen three-fourths of the stomach driven through the intact esophageal hiatus into the thorax. Incarceration and obstruction followed. Negative pressure oscillations were noted in the Levine-Wangenstein apparatus as one observes when a tube is placed in the pleural cavity. Review of literature reveals no mention of such a previous occurrence. This may prove a valuable early sign in the diagnosis of traumatic or other diaphragmatic hernias.

Management of rupture of the diaphragm is surgical and repair should be accomplished as soon as the patient's condition permits. It can be repaired satisfactorily through the abdomen or thorax. However, the latter is preferable unless there are other serious thoracic injuries or complications. Quite often there is an

associated rupture of the spleen or trauma to some other upper abdominal viscera. It has been the author's policy in combined thoraco-abdominal explorations to leave the costal arch intact.

*Gastric Dilatation:* Gastric dilatation is a not infrequent complication of thoracic trauma. Although most often occurring within the first few hours, it may occur several days later. It may be the sole explanation of shock or other signs of general deterioration such as rapid pulse, apparent respiratory difficulty, ashen color and apprehension or restlessness and can be a serious complication if it is not recognized and corrected by the introduction of a Levine tube into the stomach and the application of suction.

#### DISCUSSION

In this present day of high speed automobiles, increasing air travel, mechanization of farms and a large number of people working with other machinery, thoracic injuries are common. They are responsible for a large percentage of accidental deaths. Approximately 25 per cent of automobile accident deaths are due to thoracic injuries. The common injuries are multiple rib fractures with resulting paradoxical breathing, hemopneumothorax, laceration of lung, contusion of the heart and, on rare occasions, injury to the great vessels, esophagus, thoracic duct and diaphragm. Physical findings are often misleading and repeat roentgenologic studies and serial electrocardiograms are indicated. For example, an initial roentgenogram of the chest may show no evidence of hemopneumothorax but repeat roentgenograms several hours later may show extensive important changes. The common practice of taking roentgenograms simply to show the presence or absence of rib fractures should be discouraged. The point of major importance is the presence of intrathoracic injury or complications and not the presence of fractured ribs.

Quite often a great deal of valuable time is wasted or used unwisely in the accident room of the hospital while a roentgenogram or some laboratory procedure is being completed, or private physicians are being located. As a rule, the most inexperienced people in the hospitals are detailed to take care of the emergency room and initially treat some of the most serious cases in the hospital. Many chest injury deaths occur within the first few hospital hours or the chain of events is set up for serious complications which occur later. These are largely remedial injuries. Much can be accomplished by considering every chest injury as serious or potentially fatal.

The organs involved in thoracic injuries are of such great importance to well being that correction of deranged physiology should be as prompt and complete as possible. Immediate attention to the injuries and their deranged physiology and careful attention to the associated injuries will greatly decrease morbidity and do much to eliminate the high mortality rate incident to such injuries. Many deaths due to thoracic injuries are preventable. Most of the principles and therapeutic measures are rather simple and consist chiefly of control of pain and shock, stabilization of fractured ribs and sternum, decompression of the pneumothorax, relief of hemothorax by aspiration, maintenance of a free airway by

some form of tracheobronchial aspiration if the cough is ineffective, and occasionally open thoracotomy for control of major hemorrhage, or repair of injuries to the bronchi, trachea, esophagus or diaphragm. The heavy smoker, those with pre-existing respiratory disease or with decreased pulmonary function and the patient of advanced age, require a more aggressive approach. Smoking is prohibited. The author has been impressed by the value of tracheostomy and cortisone in the management of severe respiratory problems, be they traumatic or otherwise.

The awareness of other injuries and complications is of utmost importance. A thoracic surgeon, orthopedist, neurosurgeon or general surgeon may see a patient and immediately focus his attention upon a particular portion of the body to the exclusion of much attention to other injuries or anatomic structures which may be equally or more important. It seems preferable to have the specialist in charge of the case in whose field the major injury lies. It should be his responsibility to request adequate consultation. By managing the case in this manner, better control is maintained and the patient has a better chance of recovery. For example, a patient may have a fractured skull with cerebral concussion, a crushing injury of the chest with hemopneumothorax and paradoxical breathing, a fracture of an extremity and serious intra-abdominal injury such as a ruptured spleen or other viscera. Thus, it is obvious that no one individual is capable of taking care of all the patient's injuries or potential complications.

Blades<sup>2</sup> has pointed out that improved results in thoracic injuries are not due to surgery but rather to supportive measures. The vast majority of serious thoracic injuries do not require major thoracic surgical procedures. As one's experience broadens he performs less surgery in this group. The prognosis in most cases depends upon meticulous nursing care and very careful attention by the attending physician to a great number of minute details. Frequent visits and sometimes almost constant attention for many hours to several days is necessary. Well trained physicians of today should not continue to accept severe morbidity, long term invalidism and a mortality rate of approximately 10 per cent in patients who had thoracic injuries and were admitted to the hospital.

#### SUMMARY AND CONCLUSIONS

The frequency of severe thoracic injuries and the immediate and subsequent complications which are encountered should sufficiently impress the physician so that he will consider every chest injury as potentially fatal. The deranged physiology is often out of proportion to the apparent extent of trauma. Accident room management often determines the patient's subsequent course.

Prompt institution of the necessary emergency measures, control of pain, correction of paradoxical motion of the chest wall, maintenance of an adequate airway, relief of pneumothorax and careful observation for more unusual complications or associated injuries will greatly decrease morbidity and mortality rates. Multiple specialty consultations are often necessary. Extensive thoracic injuries in the heavy smoker, the aged, or the patient with poor respiratory reserve require very detailed attention.



General and specific therapeutic measures have been discussed in some detail. More unusual injuries or complications such as fracture of the trachea and torsion of the lung have been mentioned.

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# THE RECOGNITION OF ASCARIDES OBSTRUCTION ON THE PLAIN ROENTGENOGRAM OF THE ABDOMEN

WITH A REVIEW OF THE LITERATURE

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The use of the plain film of the abdomen has become a valuable adjunct in the evaluation of the acute abdomen. Therefore, re-emphasis of the appearance of the ascaris lumbricoides in cases of vermicular ileus on the plain film is being undertaken.

*Ascaris lumbricoides* is probably the most common parasite found in man.<sup>43</sup> The female is 20-36 cm. long and the male is 15-30 cm. long. The ova are passed with the feces and are not infective for 10-14 days, until segmentation takes place. No intermediate host is used. The soil containing the embryonated ova is taken by mouth—the larva being freed in the small intestines. The larva penetrate the intestinal wall to enter the portal circulation to be carried to the lungs. From the lungs, they migrate up the trachea and are swallowed. At this stage, they are about 2.0-3.0 mm. long but reach full development in the bowel in 8-10 weeks.<sup>43, 6 9 29</sup>

Because of the profusion of symptoms<sup>38</sup> and array of complications<sup>20, 24, 40, 38</sup> the recognition of the worm in the barium studies of the intestinal tract has long been emphasized by case reports.<sup>5, 7 8, 10-12, 14-16, 19, 23, 25, 26, 28, 33-36, 39, 41, 44-46, 48</sup> The visualization of the worm during barium studies was first described by Fritz<sup>17</sup> in 1922. The first article in the English literature was by Archer and Peterson<sup>1</sup> in 1930. In these cases the worm is either seen as a radiolucent band surrounded by barium<sup>49</sup> or else the worm ingests the barium.<sup>50, 16</sup>

The examination of the stool for ova is theoretically quite adequate for the detection of infestation as the female worm lays about 200,000 ova daily.<sup>43</sup> However, in cases in which the worms are sexually immature or in which only female worms are present, ova will not be present and the barium studies may detect unsuspected infestation.<sup>5</sup> The experience of some authors indicates that the accuracy of the barium studies compare favorably with the study of the stool specimens.<sup>11, 29</sup>

In cases of vermicular ileus, there is a theoretic danger of turning a partial obstruction to a total obstruction by the administration of barium by mouth.<sup>31</sup> In these cases the value of making the diagnosis on the flat film is most evident.

The recognition of the worm on the plain film was first described by Lenarduzzi<sup>27</sup> in 1938. This was followed by two reports by Barbieri in 1939. Two other papers on the subject were reported in 1943 and 1944.<sup>2, 18</sup> The first report in the English literature was by Skapinker<sup>42</sup> who was unaware of the previous reports. Jenkins and Beach,<sup>22</sup> Moore,<sup>30</sup> and Isaacs<sup>31</sup> have reported this finding in the last 2 years.

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FIG. 1. Plain film Case 1



FIG. 1b. Three hour delayed film after barium swallow. (Case 1)



FIG. 2. Plain film Case 2



FIG. 2b. Two hour delayed film after barium swallow. (Case 2)



FIG. 3. Plain film Case 3



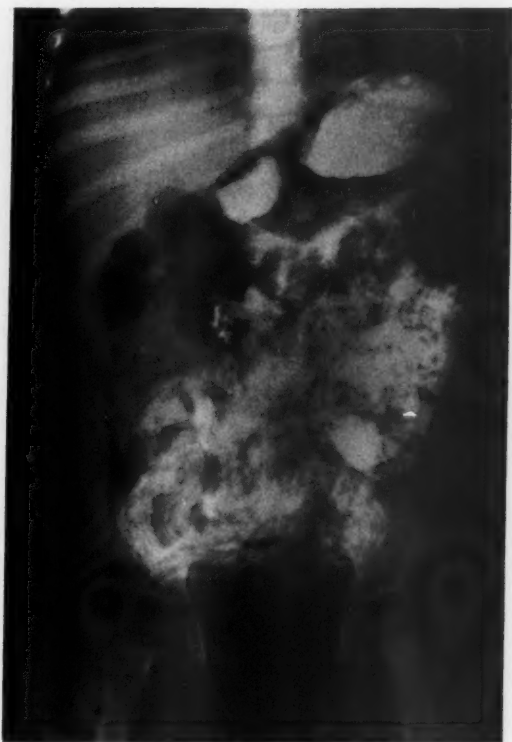


FIG. 3b. Two hour delayed film after barium swallow. (Case 3)



FIG. 4. Plain film Case 4



FIG. 5. Plain film Case 5

The worms appear in the gas containing loops of bowel as positive shadows. In order to visualize the worms, the bowel must contain gas as the density of the worm's body is the same as fluid and would therefore cause no contrast. The same fact is applicable to the bowel wall. The appearance of the worms when visualized in contrast to barium has been variously described as a "skein of yarn,"<sup>737</sup> "whirlpool,"<sup>747</sup> and partially opened package of cotton.<sup>47</sup> Isaacs described the picture seen on the plain film as something that "looks like a bunch of worms."<sup>721</sup>

The following 5 cases are not the total seen at this hospital in the last 3 years. Rather, cases are presented whose films were suitable for reproduction. No effort has been made to correlate the accuracy of the procedure in comparison with the laboratory work, nor has every case of vermicular ileus been X-rayed.

Case 1. (Fig. 1 & 1b.) This 5 year old Negro boy was admitted to the Emergency Room complaining of abdominal cramps. The child was listless, had a distended abdomen, and had vomited at home (contents not described). A plain film of the abdomen disclosed ascariides. Barium was given by mouth and a 3-hour film (1b) disclosed innumerable ascariides in the distal small bowel. The child made an uneventful recovery when given saline enemas and crystoids.

Case 2. (Figs. 2 & 2b.) This 4 year old Negro boy was admitted to the Emergency Room because of abdominal distention and vomiting. The mother stated that worms were present in the vomitus. A flat film of the abdomen showed ascariides. Barium was given by mouth and a 2 hour film disclosed the worms in the small bowel. The child made an uneventful recovery after being given saline enemas and crystoids.

Case 3. (Figs. 3 & 3b.) This 2 year old white girl was brought to the Emergency Room with an attack of abdominal pain, distention and vomiting. The provisional clinical diagnosis was intussusception. Ascariides were found on the plain film. Barium was given by mouth. The 2 hour delayed film demonstrated well the worms throughout the small bowel. Recovery was uneventful when given saline enemas and crystoids.

Case 4. (Fig. 4.) This 3 year old Negro girl was admitted vomiting worms and passing worms by rectum. Abdominal distention was also present. A plain film of the abdomen disclosed multiple ascariides. Recovery was uneventful when given saline enemas and crystoids.

Case 5. (Fig. 5.) This 4 year old Negro boy was admitted to the Emergency Room complaining of diffuse abdominal pain. The abdomen was moderately distended. A plain film of the abdomen disclosed ascariides. Recovery was uneventful when given a saline enemas and crystoids.

In cases 1, 2, and 3 the plain films of the abdomen were sufficient to establish the diagnosis. The giving of barium by mouth did permit better visualization of the parasites but perhaps added an unnecessary hazard although causing no untoward effect in these patients.

#### SUMMARY

Ascariides can be seen on the plain film of the abdomen if there is sufficient gas in the bowel to permit contrast. The visualization of the worm does not necessarily mean that its presence accounts for the abdominal pain as any pathologic state that would cause the accumulation of bowel gas (either a reflex ileus or mechanical obstruction) could result in the appearance of worms that are only incidental.

The recognition of the typical roentgen appearance of ascariasis on the plain

film could well prevent unnecessary surgery and at the least permit better overall management of the patient.

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## THE CONTRACTURE OF DUPUYTREN

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*Miami*

Although this disease was described over three and one-half centuries ago by a Swiss physician, Felix Platter,<sup>5</sup> its cause still remains in dispute. It is most interesting to follow through the years the trend of thought as to the etiology of this palmar contracture, but disappointing to bring ourselves to the conclusion that the solution remains unsolved. Baron Guillaume Dupuytren,<sup>2</sup> surgeon-in-chief of Hotel Dieu, deserves the privilege of having his name attached to this fascial deformity because he so aptly described the pathologic features and offered a method of therapy. Dupuytren's contribution has become a classic to the students of hand surgery.

Knowledge of the anatomy involved is essential to successful treatment. The skin covering the palm of the hand is a specialized structure and if lost it is difficult to substitute. It has a peculiar thickness, is hairless and exhibits characteristic whorls and flexion creases. The whorls increase tactile sensation and the center of each whorl constitutes the most sensitive part. There are various types of nerve endings called corpuscles, among which are the Pacinian, Meissner and Ruffini. The hand is able to interpret shape by protopathic (gross or coarse) sense and texture by epicritic (finer) sense. Upon removal of the skin there is found a thin layer of fat in the mid-palmar region which becomes thick over the thenar and hypothenar eminences and the heads of the metacarpal bones. Primarily the affected structure in Dupuytren's contracture is the fascia, which is composed of a superficial and a deep portion (fig. 1). This aponeurosis is pyramidal in shape with both transverse and longitudinal fibers. The origin of this palmar fascia is the transverse carpal ligament, the palmaris longus tendon when it is present (85-90 per cent of human hands), and the antebrachial fascia. The aponeurosis continues distally and merges into the interdigital ligaments (Braune's or Gerdy's natatory ligaments), the skin, and the fascial slips of the fingers. Although the function of this framework is to protect and keep the anatomic structures of the palm in steadfast relation, aponeurosectomy does not cause any remarkable disability to the hand.

Grossly, the early pathologic picture is one of aponeurotic thickening which later exhibits multiple nodular involvement (fig. 2). The overlying integument is atrophied and fibrotic, but there are also seen areas of induration and dimpling. There is a marked decrease in the subcutaneous fat. The tendon sheaths, intrinsic muscles, digital nerves and vessels are not involved. Microscopically, the aponeurosis shows varying degrees of maturity. Examination of the nodular formation presents a hypercellular connective tissue, an increase in blood vessels, leukocytes and round cells. It is because of this histopathology that authors have thought the disease to be a benign fibroplasia,<sup>3</sup> a cellular fibroma,<sup>1</sup> or a

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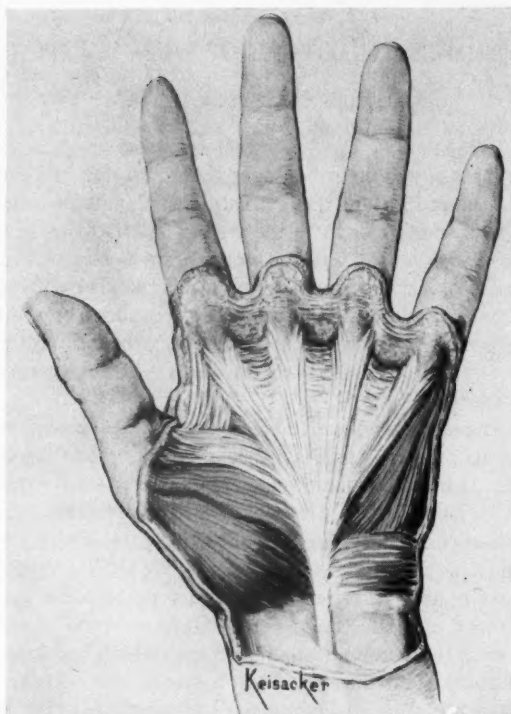


FIG. 1. The palmaris fascia is constructed of longitudinal as well as transverse fasciculi and although some anatomy texts do not illustrate a pollicis extension this is present in the human hand.

chronic inflammatory process.<sup>4</sup> One writer<sup>6</sup> in an excellent monograph, described structures that were suggestive of minute traumatic ruptures of the fiber bundles followed by excessive fibrosis, which he believes could be the etiologic factor of the disease.

Dupuytren's contracture in its earliest clinical state may be diagnosed by a palpable localized subcutaneous thickening which later develops a nodular formation. When a nodule is present on the surface and firmly adherent to the palmaris fascia it is pathognomonic of the disease. The aponeurosis next becomes adherent to the skin causing traction followed by flexion deformities of the fingers and dimpling of the integument (crescent formation) (fig. 3). Extension of the fingers becomes limited and upon passive exertion produces visible nodular cords that resemble bow-strings which are exemplified by ischemic lines. If the natatory ligaments become involved the fingers are difficult to spread apart.

The literature varies in regards to sex incidence, but the author's 21 cases compare favorably with the majority in that the disease existed in only 2 females. Familial tendencies were found in 11 of the patients. The age incidence ranged from 31 to 73 years with 18 patients between 40 and 60 years. All of the indi-



FIG. 2. The pathologic picture is one of aponeurotic thickening and contraction followed by flexion of the involved phalanges.

viduals belonged to the white race. Both hands were involved in 12 patients, the right hand only in 6, and the left hand only in 3 patients. The plantar fascia exhibited the disease in 2 patients and 1 of these was a female patient. Peyronie's disease (induratio penis plastica) was seen in 1 patient. The contracture was present in 40 little fingers, 42 ring fingers, 18 middle fingers, 4 index fingers and 4 thumbs. Knuckle pads were present in 5 patients and were tender and painful in 1 of these. This latter deformity is a nodular collagenous mass in the subcutaneous tissue located on the dorsal aspects of the interphalangeal joints. They should not be confused with Heberden's nodes which occur at the distal interphalangeal joints and are fixed to the bone. Because many other diseases have been described associated with Dupuytren's contracture, most of the patients were interrogated from this viewpoint. None of those patients questioned gave a history of diabetes mellitus, 1 had a mild case of epilepsy, none had torticollis, none were keloid formers, 1 stated he had been treated for gout and 4 were known to have arthritis. None of the patients exhibited clinical pituitary or parathyroid deficiency. Although 1 had a thyroidectomy, she did not show at that time thyroid deficiency. One male gave a history of syphilis that had been treated and was without present clinical symptoms. One patient had a previous fractured

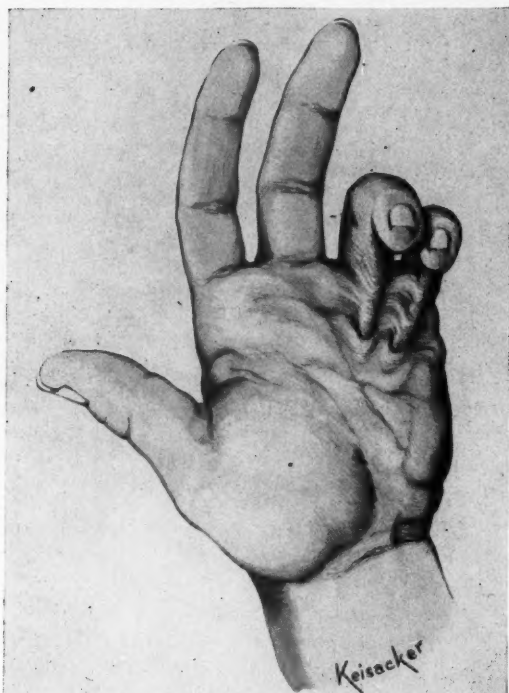


FIG. 3. The topical pathology is exhibited by integumental nodular cords (bow string) whose proximal ends demonstrate dimples or crescent formations.

humerus, and 1 stated that he was treated for a fractured radius but without complications. None of the patients gave a history of peripheral nerve lesions and 1 of the male patients had an arrested case of pulmonary tuberculosis. The occupations of these patients varied. There was 1 individual who was a bank president, 1 a bank loan officer, 1 a general surgeon and 1 an internist. There also was 1 business man who owned a lumber company, there were 3 contractors, 2 patients were housewives, 1 a hospital orderly and the rest common laborers. None of these patients gave histories of known acute severe hand injuries but some thought their conditions were due to constant or intermittent handling of working tools or implements. None of these individuals had received x-ray treatments to their hands.

In this series of cases various types of therapy were utilized mainly because some reports in the literature were suggestive of satisfactory results without surgical interference. Twelve of the patients were given Kutapressin.\* This was administered by intramuscular injections as well as injections into the diseased palmar fascia. Over a period of 6 months the patients received this type of treatment and were followed carefully. Although some of the patients were under the

\* Kremers-Urban Company.



FIG. 4. Bilateral Dupuytren's contracture showing the typical flexion deformities of the phalanges and also a knuckle pad on the dorsum of the right index finger at the proximal interphalangeal joint.

impression that the medication was of benefit while the therapy was being administered, all of them with the exception of 1, were under the impression that the medication when discontinued was of little or no benefit. One patient who had Dupuytren's contracture of both hands expressed the opinion that the scar tissue was softer and he was able to use his hands better. This could not be substantiated by the author's examination. In 6 of these patients a cortisone product was also used both parenterally and orally without noticeable results. Alpha tocopherol was of no benefit. X-ray and radium were not used in any of the patients. Sixteen of the patients have been operated upon, the surgical technic being similar in all of the patients (fig. 4, 5, 6). When the flexion deformities of the fingers were of such severity that the fingers could not be extended to any appreciable amount, a subcutaneous fasciotomy was performed with a cataract knife under a local anesthetic. The fingers were then forcibly extended to the limit of minute tears in the integument. The hand was immediately dressed with a roller bandage in the palm to inhibit return of the fingers to their flexion deformity. The hand was then subjected to physiotherapy for about 3 or 4 weeks and this was followed by a surgical fasciectomy. In those patients who did not exhibit the severe flexion contracture, the preliminary fasciotomy was not attempted. Because this condition is a progressive disease, the ideal procedure is to extirpate the palmaris fascia. Under a general anesthetic a pneumatic tourniquet was applied on the arm followed by an Esmarch bandage to assure a bloodless operative field. An incision was made immediately distal and parallel to the transverse palmar flexion crease. The integument was elevated proximal and distal leaving as much subcutaneous fat as possible attached to the skin. The flaps were handled with dermal hooks to decrease trauma to the already devitalized skin edges. The aponeurosis was not dissected to its origin on the transverse

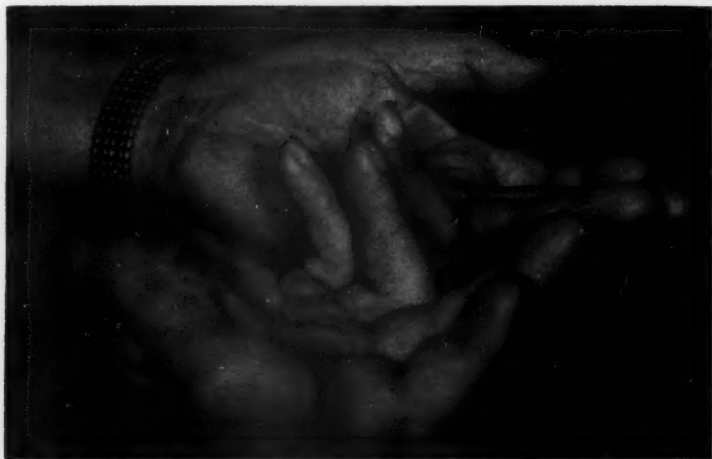


FIG. 5. Lateral view presenting the crippling defect of limited phalangeal extension. The knuckle pad is again seen on the right index finger.



FIG. 6. The patient has extended his digits to their limit. Regardless of this disease the patients develop a relatively good function unless the thumb and index finger are involved.

carpal ligament, but instead to the area where it begins to spread into the different septa. The volar digital nerves were carefully isolated and the fascia dissected from them if they were involved. Transverse incisions were made in the proximal interphalangeal flexion creases and the diseased fascia fasciculi extending to these areas were removed. When the fingers were extended the incisions became elliptical in shape. Any adjacent devitalized skin was excised. After this was achieved, the pneumatic tourniquet was released and the bleeding vessels were ligated



with no. 38 stainless steel wire. Hemostasis is important because postoperative hematomas prolong convalescence. The surgical field was then irrigated with normal saline solution and the area was examined for any possible further fascial involvement. The fingers were held in extension by sutures through the tips of the fat pads to demonstrate the denuded area to be covered. Skin flaps were then devised from the dorsum of the hand to cover the existing defect of the palm and skin flaps were also constructed to cover the small triangular defects on the palmar surface of the proximal interphalangeal joints. These skin flaps were rotated to fill the denuded defects. They were sutured into the recipient areas with

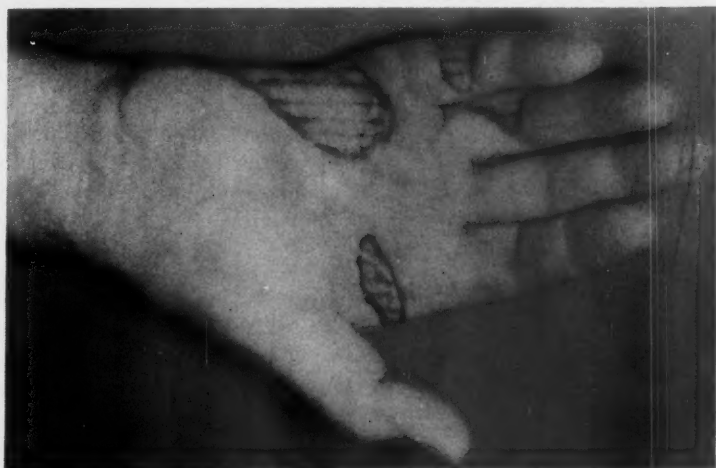


FIG. 7. The postoperative hand illustrating dorsal skin flaps utilized to cover the surgically excised devitalized integument. A full thickness skin graft has been used to relieve the contracture of the thumb-index finger area.



FIG. 8. Two months postoperative hand showing the donor sites of the skin flaps which have been covered with split thickness skin grafts. These are shrinking and may be removed later if so desired.

interrupted no. 36 stainless steel wires. The donor sites were covered with split thickness skin grafts removed from the volar aspect of the forearm. If there was an existent contracture band between the thumb and index finger it was removed and a full thickness skin graft used to inhibit scar contracture of the web space (fig. 7, 8).

#### SUMMARY

In summary, it is necessary to emphasize that each Dupuytren's contracture be treated as an individual case and the operative procedure fitted to the diseased hand. Although passive exercises and other physiotherapy maneuvers may be of help, active motion is most beneficial. The patient is advised preoperatively that he will not be able to resume extreme active duty with the hand that was operated upon for at least 1 month. There have been some patients with severe flexion deformities of the little finger, but none have been amputated. All of the patients in this series have resumed their occupations and all feel they have been benefitted by this surgical interference. Dupuytren's contracture is definitely a progressive affair and none of the hands examined exhibited regression of the symptoms presented without surgical intervention.

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## SURGICAL CONSIDERATIONS WITH GASTRIC DIVERTICULA

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True gastric diverticula are infrequently encountered, but they are by no means rare. Most of them cause no symptoms and are incidental findings at autopsy or roentgenologic examination of the stomach. When symptoms occur, conservative medical therapy is generally rewarded. The surgeon may be called upon to manage only those patients in whom the lesion results in intractable pain, retention, perforation, hemorrhage, inflammation or suspected neoplasm.

The pain associated with a gastric diverticulum is felt high in the epigastrium. The distress may be cramp-like, or dull, lasting from minutes to hours. It usually comes on after meals when the diverticulum fills; often it is aggravated at night by the supine position. The erect or prone positions may bring relief by emptying the sac. If the neck of the diverticulum is wide, the lesion is apt to be asymptomatic, while if the neck is narrow, the distress may be severe and prolonged (fig. 1). Characteristically, the pain is periodic with months between each series of episodes.

Stasis of food within a gastric diverticulum can lead to putrefaction with a foul odor to breath and vomitus. Likewise such stasis may contribute to ulceration and bleeding from a localized gastritis. By narrowing the ostium or by irritating sympathetic pathways this inflammatory factor may partially explain the variability of symptoms and the periodicity of exacerbations. Perforation and hemorrhage rarely occur. Mild hematemesis and melena are more common during an episode of recurrent attacks.

Included in the differential diagnosis of gastric diverticula are neoplasm, cardiac disease, pancreatitis, peptic ulcer, hiatus hernia, biliary disease and achalasia. Most important in the diagnosis is the radiologist who can demonstrate the gastric diverticulum with the patient in the recumbent position using barium contrast media. A careful workup should include an upper gastrointestinal series, a cholecystogram, a barium enema and an electrocardiogram. Every effort should be made to exclude other unrelated disease before attributing the patient's difficulty to the diverticulum.

A conservative medical regimen is always indicated before resorting to surgery except where a perforation has taken place or where a neoplasm is suspected. Such conservative therapy consists of a convalescent ulcer diet, antispasmodics and the liberal use of liquids after meals to flush out the diverticulum. The patient is also advised to avoid the supine position for several hours after eating. This conservatism is usually rewarded.

### SURGICAL MANAGEMENT

Gastric diverticula are approached transabdominally through a vertical or transverse incision which can be extended across the left costal margin for fur-

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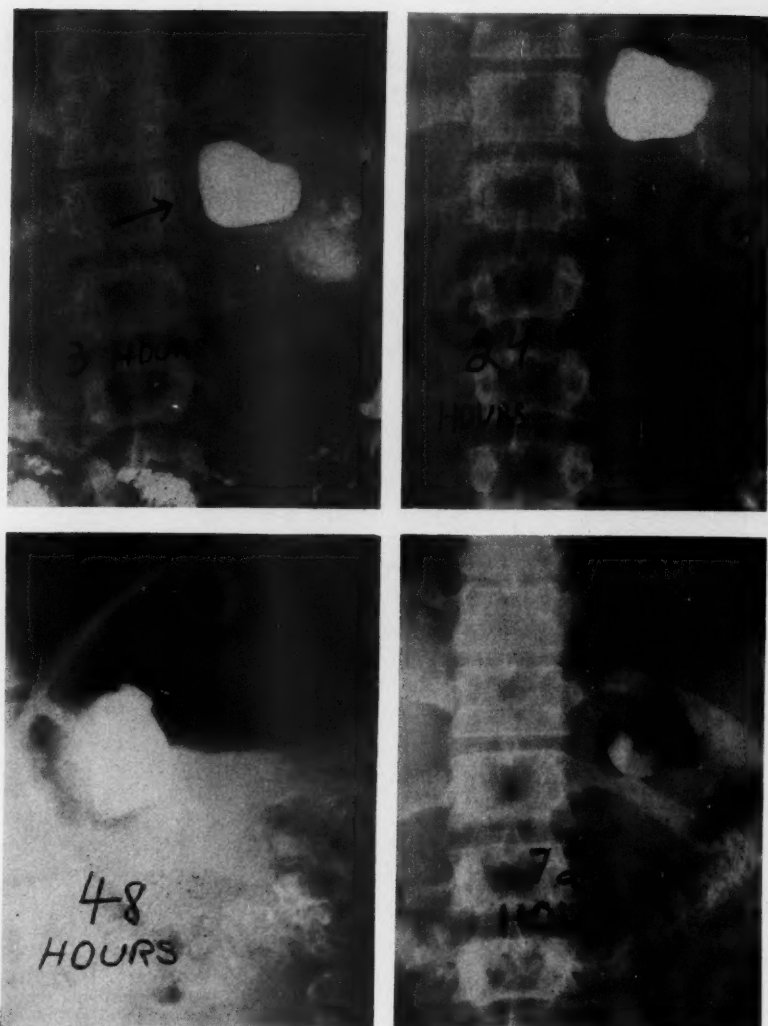


FIG. 1. Twenty-one year old white man with prolonged stasis within a gastric diverticulum. Note the narrow ostium.

ther exposure if necessary. The transthoracic and thoracoabdominal routes give ideal exposure to the esophagogastric junction and are preferred by the author.

Because the majority of these diverticula are located on the posterior aspect of the stomach near the cardioesophageal junction, they are considered rather inaccessible. Walters<sup>6</sup> has stressed that good exposure can be obtained by dividing the gastrosplenic ligament and the gastrocolic omentum so that the fundal

TABLE I

Sex	#1 Female	#2 Male	#3 Male	#4 Male
Age.....	32	21	23	32
Epigastric pain.....	Yes	Yes	Yes	Yes
Hematemesis.....	Yes	Yes		
Vomiting.....	Yes	Yes		
Melena.....	Yes	Yes		
Duodenal ulcer.....	Yes		Yes	
Fetor oris.....		Yes		
Intermittent dyspepsia..	Yes	Yes	Yes	Yes
Treatment.....	Diverticulectomy		Medical	
Result of treatment.....	Good	Good	Good	Good



FIG. 2. The ballooning effect on the diverticulum with air in the stomach.

portion of the stomach may be turned medially. Division of the left triangular ligament of the liver and mobilization of the lower abdominal esophagus will facilitate exposure also. Not infrequently the surgeon has difficulty in locating the diverticulum. Gastrotomy has been used as a means of identifying the neck;

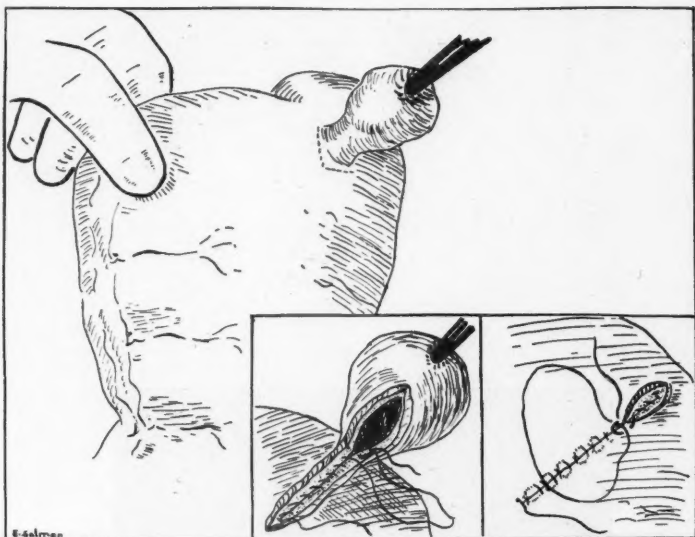


Fig. 3. A technic of gastric diverticulectomy, employing a two layer closure.

the lesion can also be demonstrated in troublesome cases by inflating the stomach through a Levin tube (fig. 2).

Resection of the lesion is the treatment of choice (fig. 3). Due to technical difficulties, a diverticulum has occasionally been inverted with a purse string suture. This method is less desirable because it causes a temporary mass defect within the gastric lumen which could result in cardioesophageal obstructive symptoms, ulceration or bleeding.

Pathologic examination of the true gastric diverticulum will show mucosa, submucosa, muscularis, and serosa on microscopic inspection. There may be a variable amount of inflammatory reaction in the wall (fig. 4). Ulceration involving the mucosa, submucosa and muscularis is looked for, but is usually absent. Aberrant pancreatic tissue has been reported in 15 specimens.<sup>5</sup>

Postoperative care after gastric diverticulectomy is similar to that employed after gastrotomy. It is considered wise to maintain the Levin tube in the stomach for 12 to 24 hours in order to keep the gastrointestinal tract decompressed until the period of physiologic ileus is over. In addition, the use of the tube and Wangenstein suction will reveal any intragastric bleeding if it were to occur from the suture line. Oral intake is withheld for 24 hours. Clear surgical liquids may safely be administered by mouth in small hourly feedings on the first postoperative day. Parental fluids may be necessary for several days until sufficient oral intake is tolerated.

A soft Penrose drain should be employed in the left subdiaphragmatic space. The drain is left undisturbed for 5 to 7 days unless the patient is febrile or is



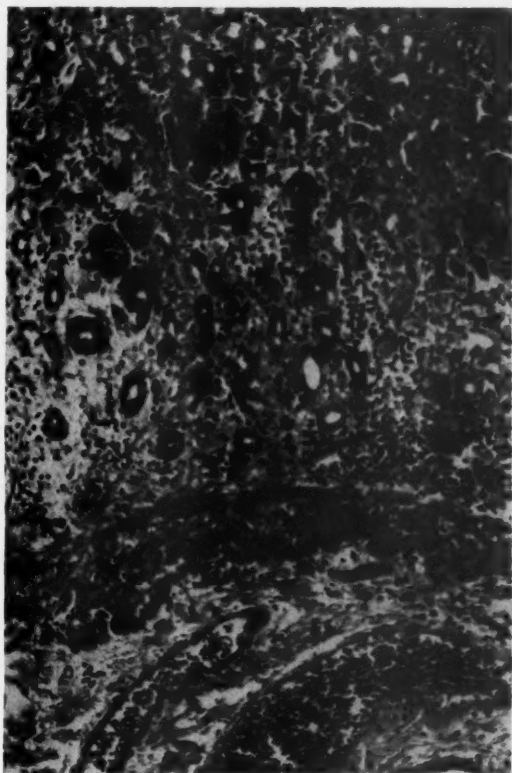


FIG. 4. Photomicrograph of the wall of a true gastric diverticulum. The thinned out muscularis layer and the diffuse gastritis are noteworthy.

suspected of having a subphrenic collection. A mere twist of the drain will free the fibrin seal for drainage. Broad spectrum antibiotics are advised as a further precaution against postoperative infection. When the transthoracic or thoraco-abdominal approach is utilized, watersealed drainage of the pleural space is maintained for 48 hours.

#### SUMMARY

While most true gastric diverticula present no serious medical problem, others may require surgical intervention due to intractable pain, retention, perforation, hemorrhage, inflammation, or suspected neoplasm. Resection of the diverticulum is the treatment of choice when surgery is necessary.

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## EDITORIAL

### SCYLLA AND CHARYBDIS IN MEDICAL EDUCATION

To denote two dangers, either of which is difficult to avoid without encountering the other, the ancients personified as two female monsters, a rock on the Lavinian shore opposite a whirlpool off the coast of Sicily. To charter a safe passage between these awesome dangers required not only a high degree of navigational skill, but also very considerable cooperation on the part of each crew member in following the captain's signals and in the exact performance of individual assignments. Such a degree of cooperation was obtainable only by keeping the ultimate goal of safe passage in mind. Malcontents dragging their oars could cause shipwreck as readily as an incompetent navigator. The ship's officers on the other hand, had not only to exercise their skills and judgments but had to so run the ship as to obtain maximal cooperation and effort from the crew.

In many ways and in many parts of the country there exists in medical education a similar Scylla and Charybdis. On the one hand we have the "*lucite towers*" from which peers the full-time academician viewing the outside world as through a "*dark glass darkly*". In close proximity is the maelstrom of the private practitioner and the county medical society. Unlike the monsters of the ancients, the dangers to the future course of medical education can be solved with a bilateral approach to mutual understanding and cooperation, the elimination of abuses on both sides and a continuing vision not only of the future goal but the past history of medical education. As Cicero has said: "Not to know what occurred before you were born is always to remain a child".

The weaknesses and evils of a vocational training approach to medical education as pointed up by the Flexner report of 1910 cannot be ignored nor can we retrogress to a similar status a half century later. Neither can we ignore the dissatisfactions and rumblings of the present which are heard in many areas. Several times in the past the surgeons of this country have led their colleagues in establishing guiding principles in residency training, specialty certification, hospital standards and other fields beyond the realm of surgery itself. Perhaps it is time for the surgeons again to charter a proper course. Our problems should not be flaunted before the local lay community or be the subject only of medical-political and medical-organizational meetings (formal and informal) but should be discussed seriously, cooperatively and without vituperation in our specialty meetings and our specialty journals.

Thoughtful practitioners and teachers of medicine can recognize the danger of abuses which can occur bilaterally at the individual level. It is as totally wrong that an academician capitalize on his academic stature for personal aggrandizement and financial gain as it is for the practitioner-teacher to shirk the responsibilities of his academic appointments to capitalize on the prestige of the position for his aggrandizement and financial gain. On a broader basis, it is no more right that an educational institution seek to finance its program in medical education through the corporate practice of medicine than it is that organized medicine

seek to restrain the occupants of the "*lucite towers*" from the rights and privileges accruing to qualified and licensed Doctors of Medicine. It is as much of an imposition on the academician's code of medical ethics to be forced into providing support of his institution's program through his own medical activities as it is a violation of his code of academic ethics to be forced into the acceptance of principles and practices of strict academic nature by the dictates of organized medicine.

It is our opinion that there are several basic tenets which must have bilateral acceptance in order to charter a safe course. That these tenets have some foundation in fact can best be supported by pointing out our belief that these tenets, strictly adhered to, have accounted in part for the very considerable cooperation, help and understanding extended to the Department of Surgery of the University of Miami School of Medicine by the physicians of Dade County in the relatively brief period of existence from its founding in 1952 to the graduation of its first class and accreditation by the proper committees in 1956. These basic concepts are as follows:

Medical school faculties should embrace both a nucleus of full-time or geographic full-time men and a coordinated group of voluntary teachers. Certainly, this plan is subscribed to by organized medicine's own House of Delegates which made such a recommendation to the Council on Medical Education many years ago.

The academic surgeon's primary obligation is education, investigation and service. This does not in itself preclude a role in referred private practice as long as the secondary role, through proper safeguards and individual responsibility, does not interfere with the primary objective.

While many of the most valuable teachers are members of the voluntary staff, the acquisition of an M.D. degree does not carry with it a guarantee of the teaching ability of the acquirer nor is it a measure of his talent as an educator.

Full-time or geographic full-time teachers can and must make a far greater contribution to an educational program for undergraduate medical students and graduate house officers than voluntary teachers whose primary concern must of necessity be the maintenance of a successful practice.

Just as a surgeon is responsible for and must maintain jurisdiction over the management of a surgical patient during the preoperative, operative and post-operative course even though anaesthesiologist, internist, pathologist et al. participate, as consultants, in the ultimate care of the patient, so too in the medical educational process, the responsibility of jurisdiction and management must rest in the hands of the professional educator with the voluntary teacher acting as a consultant and advisor—not as an organized legislator.

Medical students as such are not being trained specifically for any one of the myriad segregated fields ranging from generalist to investigator. The aim of a medical school should be a graded educational program, the ultimate aim of which is a broad and sound background in the field of medicine upon which the student may develop, later, his special talents whether those talents lie in general practice, a specialty field, the investigative laboratory or the academic life.

The undergraduate and graduate student must be indoctrinated in the social, economic, spiritual and moral aspects as well as the scientific aspects of medicine. Just as a surgical resident cannot be taught his specialty by a nonsurgeon, neither can the student be prepared adequately for the private practice of his art and science by the responsible individuals in charge if they have no contact with the trials and tribulations as well as the joys and rewards of private practice.

In order that well-qualified teachers be attracted to and retained in the academic field, a medical school must furnish a basic salary to its full-time teachers. This should come from university funds, not from the private practice activities of the teacher or other physician. Since few universities can afford to provide salaries commensurate with the earnings that the teacher could expect if he were in the private practice of medicine, a compromise must be effected by permitting the teacher a limited exercise of private practice privileges under the strict control of the Dean of the School and the Chairmen of the Departments.

The rights and privileges of the private practitioner must be guarded as zealously by those responsible as the rights and privileges of the academician.

Due acknowledgement of the valuable role of the private physician practicing in the teaching hospital must be made but the standards of clinical practice, surgical audit and review of cases must not be different for the private practitioner than the academician.

While the hospital of the medical school must be under the control of the medical school administrators this does not in any way lessen the role of the private practitioner in that hospital or his right to adequate and fair representation on the administrative boards thereof.

There are few who would quarrel with these basic tenets but there are some who would modify their interpretation to their own purposes. It is acknowledged that the location, financial structure of the school and the clinical material available for teaching purposes precludes the application of some of these tenets in certain areas and in certain schools. However, adequate liaison between the protective forces on both Scylla and Charybdis in small, workable groups can solve the problems common to both. A profusion of signals brought about by highly vocal groups on both sides in any community can serve to shipwreck medical education and in so doing shipwreck the private practice of medicine as it exists today.

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(The University of Miami School of Medicine is one of the most recently developed four year medical schools. Consequently we have received numerous inquiries about all aspects of our program including the approach of the various clinical departments in establishing harmonious relationships with the practicing physicians of a large community where a private institution has established a medical school.)

## BOOK REVIEWS

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*The editors of THE AMERICAN SURGEON will at all times welcome new books in the field of surgery and will acknowledge their receipt in these pages. The editors do not, however, agree to review all books that have been submitted without solicitation.*

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*The Atlas of Anatomy.* By J. C. BOILEAU GRANT. 4th ed. Published by the Williams and Wilkins Company, Baltimore, Md.

The fourth edition of Dr. Grant's Atlas of Anatomy is beautifully illustrated and a complete work. The many anatomic plates are very well done, clearly labeled, and the associated text is clear and concise.

There are approximately 50 new pages of illustrations in this new edition. The great majority of these are concerned with the head and neck, however the upper and lower extremities also receive their share of additional illustrations.

There are 6 new pages containing 20 of the most revealing illustrations concerning the paranasal sinuses. There are 6 new pages concerned with the anatomy of the teeth, mandible, maxilla and with dentition.

This Fourth Edition is a marked improvement on an already superb Atlas of Anatomy.  
BEN ADELSTEIN, M.D.

*The Management of Fractures, Dislocations and Sprains,* 6th ed. By JOHN ALBERT KEY AND H. EARLE CONWELL, C. V. Mosby Corporation.

The Sixth Edition of "Fractures, Dislocations, and Sprains" by Key and Conwell is an adequate and useful text for both the student and practicing physician.

A comprehensive coverage of orthopaedic trauma is presented in a short, concise manner enabling one to obtain a satisfactory knowledge of pathologic states without extraneous and relatively academic material. The subjects are well indexed and categorized and then further subdivided into the following headings:

- 1) Occurrence and Mechanism.
- 2) Pathology.
- 3) Diagnosis.
- 4) Treatment.

This facilitates the rapid familiarization of these conditions to the practitioner and offers several modes of treatment depending on the practitioner's skill and facilities while pointing out the pitfalls of various modes of treatment in inexperienced hands and with improper equipment.

The verbal descriptions are accompanied by excellent graphic illustrations, clear and readable roentgenograms and photographs which further clarify and visualize the topics being discussed.

I consider this text a valuable addition to any library but it is particularly recommended to the surgeon and the occasional orthopaedist.

MICHAEL J. FOLEY, M.D.

*Operative Surgery, Vol. I.* By CHARLES ROB, M. C., M. CHIR., F.R.C.S., Professor of Surgery St. Mary's Hospital, London, AND RODNEY SMITH, M. S., F.R.C.S., Surgeon, St. George's Hospital, London. Butterworth and Company Ltd., London, 1956.

*Operative Surgery* is a two volume publication designed to convey to the reader operative methodology primarily by visual means. Operative procedures are described in stages and the emphasis of the authors and editors has been placed on illustrative description. The accompanying text in each instance is brief, concise and pointed. The authors have utilized minimal written material to maximum advantage in clarifying in operative chronology the



steps of each operative procedure and in discussing difficulties or hazards which might be encountered.

This volume has been divided into three parts: I. General Technique—includes descriptions of such fundamental surgical methods as positioning, hemostasis, suture material and methods, exposure, techniques of regional anesthesia, drainage, biopsy, wound dehiscence etc.; II. Surgery of Trauma—includes descriptions of operative procedures for trauma in regional areas including soft tissue, orthopaedic, abdominal, genito urinary, thoracic and maxillo facial areas; and III. Surgery of the Abdomen—this part of volume I is divided into two sections which include: 1. General principles of abdominal surgery and 2. Surgery of the stomach and duodenum.

The impressive list of contributors to Volume I is obviously composed of men who have particular interests and special skills in their respective fields.

This publication should be a welcome addition to the library of the experienced surgeon and the student of surgery.

ARLIE R. MANSBERGER, JR., M.D.



